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OFFICE, CHIEF OF ORDNANCE
RESEARCH AND DEVELOPMENT DIVISION

Artillery

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ANTITANK ARTILLERY

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ANTITANK

Introduction

Although tanks made their first appearance in World War I, they were neither a decisive factor in battle nor capable of operations as an independent force. The tank was then a slow, cumbrous vehicle lacking heavy armor or great firepower. It suffered constantly from mechanical failures and was vulnerable to the fire of light field pieces, Its effectiveness was limited to circumstances of surprise employment.

Between 1919 and 1939 steady progress was made in tank design. At the outbreak of World War II the tanks of leading military nations were powerfully armored and powerfully armed. They were capable of high speed, mechanically reliable, and prepared to play a vital and aggressive part in battle.

The ease with which the German army overran Poland and France was considered proof by many observers that mechanized forces were the dominant and irresistible element in attack. Russian successes against Panzer units were dimmed by the brilliance of German tank operations in the Balkans and Libya. Military experts asserted that the importance of artillery and infantry had become secondary to that of armored forces, that tanks could conduct vast strategic maneuvers, and that the task of the infantryman had become merely one of mopping up and of subsequent occupation.

That this was a mistaken judgment ~~has been~~ was clearly demonstrated by the Russians in Europe and by the British in Libya where highly mobile guns of calibers ranging from 20-mm to 75-mm, with relatively short effective range and accompanying high velocities, were the principal factor which broke the force of armored drives.

As early as 1937, the United States Army had begun work on the design of a modern 37-mm antitank gun which was considered adequate against the armor plate then employed. The British relied heavily on their 2-pounder (37-mm) and 6-pounder (57-mm) antitank guns at the outset of the war, while the Americans concentrated on developing an improved 37-mm gun and a 75-mm gun.

When the Allies joined battle with German tanks, they had to meet not only thicker armor and more powerful armament but also the fire of new and more deadly guns. Notable among these new weapons was the German 88-mm gun which was mounted in tanks and also used against them. Not until American tanks, armed with ~~76-mm and 3-inch~~ 90 mm. guns became realities, was the destructive power of this combination equaled. Gun versus armor competition had been resumed, and against light and medium tanks the gun appeared to have gained ascendency.

Unless they were employed at close range and had high muzzle velocities, small caliber guns and antitank rifles were relatively harmless. The development story of antitank guns, when viewed chronologically, shows Ordnance designs progressing steadily from small caliber weapons to increasingly heavy pieces. A the same time the essential characteristics-- low silhouette, mobility, high velocity, flat trajectory, and increased armor penetration-- were maintained.

In the fall of 1942 a 50-mm gun was proposed for mounting on the standard 37-mm antitank carriage, which was intended to have a muzzle velocity of 2,600 feet per second. Its primary purpose was to provide the Airborne Command with a light yet effective antitank weapon. But before design studies had been made, still larger guns were considered, specifically the 57-mm gun of British origin, which we were already manufacturing for Great Britain under Lend-Lease.

Standardization of the American 3-inch antitank gun followed soon, and this weapon, together with an American version of the British 6-pounder, and the 37-mm gun, served effectively throughout the period ending in the defeat of Germany.

This phase of antitank development was one of expediency and improvisation. Reliable weapons were needed in the shortest possible time. But Ordnance Research and Development engineers bent continual effort toward the design of a weapon which would sacrifice none of the mobility needed, and yet would be capable of even greater armor penetration. In general, antitank guns fall into two types, either those developed during the first phase of the war, which were a combination of already standardized components (such as the 3-inch antiaircraft gun mounted on the 105-mm howitzer carriage), or those of entirely new design which were specifically evolved for ideal antitank use.

Experiments with tapered bore weapons were the first to take this direction in design for specific antitank employment. There the problem was less that of weight or mobility than that of difficulty of designing a reliably deformable projectile which could be put into mass production, and boring and rifling the tapered interior of the tube. The problem was eventually dropped, as too many difficulties were inherent in the complexity of the design.

The later and much more successful means of achieving deep armor penetration was embodied in the development of a series of high velocity guns 76-, 90-, and 105-mm in caliber. Velocities as high as 3,500 feet per second were achieved by lengthening the gun tube and by enlarging the chamber to take a shell with a greater propelling charge. Carriage weight was held to a minimum, and experiments with new light weight alloys were being made early in 1945 to reduce the weight of component parts. Success

along these lines had not yet been equalled by any other nation, nor had our development work by any means reached its final and conclusive stage. The antitank weapon came a long way since 1940 when wide use by Russian front line troops of antitank rifles spurred the United States to experiment with a somewhat similar weapon, firing a .60 caliber, 1,200 grain AP bullet.

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CALIBER .90 AUTOMATIC GUN

Reports that aircraft used in the Spanish Civil War were armed with 15-mm guns, and rumors of even heavier airplane armament, influenced the United States Army in developing a caliber .90 machine cannon. The design of the first model T1, a recoil operated gun, was approved in April 1937. Work on succeeding models, T2 and T3, began in January 1938. Both of these guns were of the blowback type. The T2 incorporated the differential recoil principle, wherein the round is fired approximately .6 inch from its "home" (Battery) position in the gun chamber, the cushioning effect of the powder gases checking the forward movement of the counterrecoiling parts and reducing the initial velocity of the recoiling parts. In the T3 the round was fired approximately .125 inch from the "home" (Battery) position, the forward motion of the counterrecoiling parts being checked by the counterrecoil hydraulic buffers, while the initial velocity of the recoiling parts was controlled by orifices in the buffer chamber. In both guns springs absorbed the remaining energy in the recoiling parts and returned the guns to battery.

In November 1938, while the T1, T2 and T3 guns were still in the process of manufacture or awaiting test, it was decided to produce a pilot model of an additional caliber .90 automatic aircraft gun, the T4, the design based on the recoil-operated 37-mm (Browning) Automatic Antiaircraft Gun M1A1. The rifling was to consist of 10 grooves with a uniform right-hand twist of one turn in 30 calibers. Muzzle velocity was fixed at 2,700 feet per second, and the cyclic rate was to be "the maximum that will insure reliable functioning." The T4 had a total weight of 170 pounds-the barrel

accounted for 53 pounds-and could be broken down into two loads.

Although the T4 was developed to provide an automatic aircraft weapon of great striking power, the need for an antitank gun more powerful than the caliber .50 machine gun but lighter and with greater mobility than the 37-mm Gun M3, caused serious consideration of the T4 for this purpose. It was thought that this gun, mounted on a tripod mount, or on a mount similar to that of the 20-mm Solothurn, might meet the need of the Infantry and Cavalry for a light but effective antitank arm that could be transported manually or on pack animals. Investigation of the 20-mm Solothurn gun, with a view to its possible adoption, was proceeding at the time, and the difficulties involved in the purchase or manufacture of a foreign weapon would be obviated by the successful development of a gun of domestic design.

Inability to increase the effectiveness of the caliber .50 machine gun by raising its muzzle velocity constituted another reason for attempting to adapt the caliber .90 gun to antitank use. Tests with experimental double base powders and enlarged cases proved that velocities of up to 3,300 feet per second were obtainable, but the increase in penetration was only .12 to .16 inch. This was insufficient to warrant the production of a special gun to fire the enlarged cartridges which would not be interchangeable with standard ammunition in existing .50 caliber guns. It was plain that little could be accomplished in a tactical sense by straining to increase the potential of the caliber .50 weapon which still would be ineffective at 300 yards against vehicles with armor thicker than the one-half inch plate of scout cars.

The next larger vehicle after the scout car which would be a tactical objective for these guns was the light tank with one and one-half inch armor. Penetration of one and one-half inch plate at battle ranges was beyond the capacity of the caliber .60, caliber .90, 20-mm Solothurn, or the 20-mm Hispano-Suisa guns. The smallest gun capable of stopping light tanks was the 37-mm Antitank Gun M3. It was recognized, however, that between the scout car and the light tank there might be targets with intermediate protection, and that weapons intermediate between the caliber .50 machine gun and the 37-mm antitank gun might be required.

On 14 and 20 March 1941 tests were held at Aberdeen to determine comparative performances of the caliber .90 Automatic Gun T4 and the 20-mm Solothurn T3. The T4 was fired from both a tripod mount and a two-wheeled Solothurn mount. The gun was free, with no elevating or traversing mechanisms on either mount. Traversing and elevating the gun for tracking moving targets was easy but not very accurate. Recoil reaction in both cases was too heavy and resulted in permanent deformation of the trails of the Solothurn mount.

Against one and one-quarter inch armor plate at 20° obliquity the T3 Solothurn obtained complete penetration at 100 yard range with only one of the two rounds fired. Complete penetration of one and one-quarter inch plate at the same range was effected by both rounds from the caliber .90 T4.

It was concluded that the T4 gun functioned reasonably well, but was entirely too heavy and unnecessarily complicated for

ground use and semi-automatic fire, and took too long to break down. The mounts were found to be too light for the recoil energy of the gun.

An examination of recovered projectiles showed that they were not suitable for armor piercing use.

As a consequence of the test it was recommended that the gun ~~the gun~~ be made 60 to 70 pounds lighter, as full automatic fire was not needed for ground use. A new mount, modeled after the Solothurn antitank mount, but stronger and more stable, was recommended. It was requested that removal of the barrel be made easier, that a wider, larger handgrip be provided, and that the trigger travel be shortened. It was also directed that the AP projectile be modified for better armor penetration. The projectiles fired in the test were improvised shells, used because there had not been time to develop suitable projectiles for the T4 gun.

Dvp. dropped, never canceled.

References

OCM 14279, 4 February 1938, approves design studies and manufacture of pilot caliber .90 Automatic Gun T2.

OCM 14766, 3 November 1938, recommends design and manufacture of a pilot caliber .90 Automatic Gun T4 (Colt) and lists general military characteristics.

Aberdeen Proving Ground, First Partial Report on Test of Caliber .90 Automatic Guns and First Report on Development Test of Caliber .90 Automatic Gun Manufactured by the Colt Company, O.P. No. 5490, 10 April 1941.

CALIBER .90 AUTOMATIC GUN T4

Gun

Caliber	Cal. .90
Length, overall	80.5 in.
barrel	67 in.
Weight, gun without mount (approx.)	170 lb.
sleeve	4 lb. 15 oz.
lock frame	6 lb. 5.5 oz.
receiver	106 lb. 3 oz.
barrel	53 lb. 5 oz.
Rifling, number of grooves	10
depth of grooves	.01 in.
width of grooves	.1577 in.
Twist, uniform right hand	1 in. 30 calibers
Feed	right and left hand
Muzzle velocity	2,700 ft./sec.

Mount

Model	Tripod, or 2-wheeled Solothurn
Elevation	Free
Traverse	Free

20-MM SOLOTHURN GUN

In June 1938 the Cavalry, the Infantry, and the Marine Corps expressed their desire for an individual antitank gun more powerful than the caliber .50 machine gun. The 37-mm antitank gun, then under development, did not answer the need that existed for a light weapon that could be manually transported by two men, be mounted on a horse-towed carriage, or be carried by a horse as a single pack load. Experimental work was progressing with the caliber .90 machine gun, in the hope that it might be adapted to antitank use; but since this weapon was primarily designed for aircraft armament it was considered essential to obtain a gun which would meet the requirements of the Infantry and Cavalry and have the sole function of anti-mechanization defense.

The 20-mm Solothurn Gun, manufactured in Switzerland by the Waffenfabrik Solothurn A.G., was found to possess characteristics closely approaching those stipulated by the using arms. Two Solothurn guns, together with 2,000 rounds of ammunition, were bought for test by Aberdeen Proving Ground, the Infantry Board, and the Cavalry Board. In these tests both gun and ammunition were unsatisfactory. Poorly designed ammunition and a muzzle velocity of only 2,399 feet per second gave little more penetration than that of standard caliber .50 AP projectiles. Another disadvantage was poor bipod footing which resulted in severe recoil reaction when fire was conducted from hard ground, ~~and caused~~ causing the bipod to dig into soft ground to an extent that necessitated resetting the gun after six to ten rounds had been fired.

After conference with the manufacturer a new model was

shipped to the United States and was demonstrated at Aberdeen on 16 April 1940. The gun was a magazine fed, recoil-operated, auto-loading weapon which could be fired from either a two wheeled mount or a bipod. It employed high explosive and armor piercing shells weighing from .292 to .322 pounds.

The semi-automatic recoil operation of the gun was in four phases. In the first millimeter of recoil the barrel, bolt and locking cylinder moved rearward together. In the next 32 millimeters the barrel, bolt, and locking cylinder continued to the rear, and the bolt, locked to the barrel by a cylinder into which the barrel and bolt each fitted, was gradually unlocked by the rotation of the locking cylinder acting on cams. In the next 12 millimeters of recoil the barrel and locking chamber actuated an accelerator which kicked the bolt to the rear and forced the barrel locking assembly to engage with the locking chamber, thus holding the barrel in the rearward position. The bolt, now free of the barrel, continued to the rear, cocked the firing pin spring, ejected the empty cartridge case, and compressed the driving spring until the bolt buffer met the backplate. The bolt then started forward on the return cycle. A fresh round was shipped from the magazine and fed into the chamber as the bolt met the locking cylinder. Bolt, barrel, and cylinder were locked by a reversal of the camming operation described above. A safety latch prevented firing until the action was locked. The flat magazine box held ten rounds and was inserted from the left.

The Solothurn gun was furnished with a muzzle brake which

deflected the gases sideways instead of to the rear towards the gunner. Cocking for the initial round was effected by turning a cocking handle. The gun could be field stripped by hand in about 20 seconds and reassembled without tools in about 30 seconds.

The sighting system consisted of a two and three-quarter power telescopic sight with range graduations of 1,200 meters at intervals of 100 meters. The sighting blade within the telescope could not be deflected for wind corrections, but graduation on either side of the sighting blade allowed for wind corrections and leads to be taken against moving vehicles. Since the telescopic sight was made as an integral part of the gun, it was not removable.

Tests of the new model Solothurn at Aberdeen were so favorable and indicated such improvement over the earlier model that more extensive tests were considered warranted. The gun was found to be safe, reliable, mobile, easy to transport, and accessible for replacement of parts in the field. The telescopic sight was highly satisfactory. Firing showed that AP shells would penetrate one and one-quarter inches of perpendicular armor plate at 100 yards. Claims for the ammunition supplied were that it would penetrate one inch of face hardened plate with an inclination of 20^{o} at 400 to 500 yards, and that it might be expected to penetrate one and one-half inches of such plate at 100 yards with normal impact. Muzzle velocity was found to vary from 2,821 feet per second to 2,952 feet per second for the various projectiles fired.

Tests of the Solothurn gun made by the Cavalry Board were concerned largely with its possible use as a pack weapon, for which use it was concluded the telescopic sight must be replaced by a

removable sight, and that the handles must be removed from the muzzle end of the gun to bring the weight within the 200 pound limit for cavalry pack loads. The report stated that it was practicable to use the gun in scout cars, combat cars and tanks, although, in the case of the last two vehicles, the length of receiver presented a serious problem. The report also asserted that ballistic and packing tests indicated that the Solothurn was superior to the caliber .50 machine gun as an anti-mechanization weapon for cavalry use. The Chief of Cavalry thereupon recommended its adoption as standard.

The Infantry Board also tested the Solothurn gun at Fort Benning, Georgia. The report of this test claimed that the Solothurn was superior to the caliber .50 machine gun in penetration, ease of tracking a moving target, telescopic sight, rapidity of going into action when mounted on its carriage, and in the amount of kick to the firer. The Solothurn was found to be equivalent to the caliber .50 machine gun in ease of transportation on its carriage, field stripping, flash, concealment in firing position either on the carriage or bipod, mobility except when broken down and carried manually, and in replacement of component parts. The caliber .50 machine gun was found superior to the Solothurn in mobility when broken down and manually transported, and in amount of muzzle blast. Analysis of these comparisons led to the decision that the Solothurn was generally superior to the caliber .50 machine gun for front line infantry use, and that it should be adopted as a standard infantry weapon.

The recommendations of the Cavalry and Infantry Boards were followed by standardization of the Solothurn gun for limited procurement as 20-mm Automatic Gun T3, with telescopic sight (Telescope T16),

and the two-wheeled carriage as 20-mm Gun Carriage T3. Authorization was given to procure 50 guns and 50,000 rounds of ammunition.

Purchase of these guns and the ammunition was suspended pending negotiations with the Solothurn Company for manufacturing rights. The negotiations were slow and unsatisfactory, the quotations seemed excessive, and since it would take six months to obtain and test the guns, and another year or two after signing the contract before it would be possible to get into quantity production, the project was canceled. This action was taken more readily because the 20-mm Birgkit gun, which had almost as much penetrating power as the Solothurn, was about to be produced in the United States and might be adapted to antitank use.

REFERENCES

OCM 14648, 25 August 1938, recommends purchase of two Solothurn guns and ammunition for test.

OCM 15879, 13 June 1940, summarizes APG Report that original Solothurn gun and ammunition tested were generally unsatisfactory, and recommends adoption of new model as limited procurement type under designation of 20-mm Gun, Automatic, T3.

OCM 15952, 18 July 1940, authorizes procurement of 50 guns and 50,000 rounds of ammunition.

OCM 18814, 13 September 1942, recommends cancellation of project for 20-mm Automatic Gun T3. Approved by OCM 18935.

O.O. 472.54/6578, 2 June 1938, from the Chief of Cavalry to the Chief of Ordnance, on "Individual Antitank Gun."

O.O. 472.93/5732, 16 August 1938, from the Chief of Infantry to the Chief of Ordnance, discusses purchase of weapon.

O.O. 472.91/2202, 7 May 1940, from Cavalry Board to Chief of Cavalry reports on tests of 20-mm Solothurn Antitank Gun, 818-1010.

O.O. 472.91/2220, 18 May 1940, from Infantry Board to Chief of Infantry, forwards Infantry Board Report No. 1133, "20-mm Solothurn Antitank Rifle."

3rd Indorsement to O.O. 472/54/6578, from the Cavalry Board to the Chief of Cavalry, submits recommendations for military characteristics, 26 July 1938.

1st Indorsement to O.O. 472.91/2202, from Chief of Cavalry to Chief of Ordnance, recommends adoption of Solothurn Gun as Standard, 22 May 1940.

1st Report on OP No. 5082, APG Report, "Report on Test of 20-mm Antitank Rifles 18-100°." 13 February 1939.

122nd Partial Report on OP No. 5082, APG Report, "Second Report on Tests of 20-mm Solothurn (New Model) Antitank Rifle and Ammunition." 7 May 1940.

OKD 472.95/48.1 --- No. 1, 2, and 3 --- Waffenfabrik Solothurn A.G., Solothurn, Switzerland " Le nonveau fusil anti-tank S18-1000 caliber 20-mm ," "Quelques considerations sur le fusil antitank caliber 2 cm., " " Chariot de tir SO 9 a deux rones pour le fusil antitank S18-1000" circa 1939.

20-MM AUTOMATIC T3 (SOLOTHURN)

Gun Tube

Caliber	20-mm
Length, complete	69.50 in.
without barrel	40.75 in.
barrel	36.50 in.
Weight of barrel assembly	45 lb.
Magazine capacity	10 rd.
Weight of magazine, empty	4.8 lb.
loaded	12.4 lb.
Range (effective)	300 yd.
Muzzle velocity (Paula Massive Projectile)	2,866 ft./sec.
(Anna Paula)	2,950 ft./sec.
Weight of projectile (Anna Paula)	2,254 gr. (.322 lb.)
Rate of fire	300 rd./min.

Recoil Mechanism

Length of recoil of barrel and sleeve	2.50 in.
Length of recoil of breechblock	12.625 in.

Carriage and Mount

Weight of gun and bipod (without barrel assembly)	54 lb.
Weight of gun and bipod (without ammunition)	99 lb.
Weight of carriage	218 lb.
Elevation (approximate)	12°
Traverse, gunner sitting between trail legs	35°
Maximum firing height, carriage	26 in.
Minimum firing height, carriage	12.50 in.

TD 694

20-mm ~~American~~ Solothurn in traveling position

FM 90

German Solothurn, 2 cm Pak, s/8-1100

20-mm (Solothurn) semi-automatic antitank gun, showing lowest vertical height and traveling position

TD 695

20-mm Solothurn Gun, field stripped

field stripped

TD 692

37-MM ANTITANK GUNS

The 37-mm antitank gun used by the United States Army superseded the 37-mm Gun M1916, which was the infantry accompanying gun of the American Expeditionary Force in World War I, and the standard 37-mm weapon of the Army until 15 December 1938 when the M4 carriage was standardized.

Prior to the Armistice of 11 November 1918, artillery especially designed for defense against tanks did not exist. Such opposition as tanks encountered came from ordinary field guns, machine guns, grenades and rifles. The 37-mm gun of the period was of French design, its primary purpose being the destruction of pill boxes and machine gun nests. Isolated machine gun nests were relatively easy to reduce by flanking, but when they were so grouped that they could protect each other, it became necessary to destroy certain of them in order to out-maneuver the rest. The attacking infantry could not always depend upon prompt aid from the divisional artillery, because of its distance behind the front and the difficulty of indicating to battery commanders the exact location of targets. It therefore became essential to provide the infantry with an accompanying gun light enough to be moved by hand and sufficiently powerful to eradicate pill boxes.

The 37-mm Gun M1916 mounted on a carriage with an elevation of from -14° to $+21.50^{\circ}$, and a traverse of 42.5°, had a maximum range of 4,200 yards when firing a high explosive shell weighing 1.234 pounds, at a muzzle velocity of 1,276 feet per second. The carriage was of the split-trail type, mounted on wooden artillery wheels with steel tires. It was possible to fire the gun either from the wheels, or

without the wheels and axle. In the latter case the spread trail and a front jack formed a tripod. As gun and carriage weighed but 360 pounds, they could be towed by animal or man power, or broken down into three loads for manual transport.

After the war a few carriages were designed which were modifications of the M1916. The 37-mm Gun Carriage M1916A1, with hinged trails to provide for packing, was intended for infantry use and could be divided into two pack loads. For the cavalry, Carriage M1916E1 was designed with the trails upper section shortened, and the hinge joint modified to permit rapid separation. Carriage M1916A2 was a pack development with split telescoping trails and no wheels. Known as the "Heavy Mount", it fired from a tripod. Only 16 were made and issued to the Cavalry.

Battle experience in 1917-1918 had demonstrated the need for an accompanying gun of higher velocity, greater range, and more effective ammunition than were characteristic of the 37-mm Gun M1916. Efforts were therefore made to obtain an all-purpose gun of the howitzer type which could be used in both flat trajectory high velocity, and high angle low velocity fire. The weapons built to meet these specifications were a 1.8-inch howitzer and a 2.24-inch howitzer. Tests of these howitzers resulted in a decision by the Ordnance Department that they were impracticable, chiefly because the AP ammunition designed for them had poor penetration, while the HE projectile would not remain stable at lower trajectories and still strike nose first when fired at extreme elevations. This erratic behavior of the HE projectile was due to elongation of the shell to increase its explosive content. It was also decided that the carriage was not

fundamentally of sound design, that it was too frail, and that it had insufficient traverse.

Conferences between the Ordnance Department and the Infantry Service brought about a decision to produce a weapon for each type of fire. This occasioned the creation of a 2.24-inch mortar, a 75-mm mortar, and the 37-mm Infantry Gun M1923.

A report of the Infantry Board in July 1924, following the test of the 37-mm Gun M1923, stated that, while the weapon was generally satisfactory, its instability in fire, because of its light axle load and the type of trail, together with its limited traverse, made it impractical for use against tanks. To overcome these defects the tube and recoil system were placed on the axle, while artillery wheels and a non-telescoping box trail replaced the disk wheels and telescoping tubular trail originally used. The redesigned M1923E Carriage, designated 37-mm Gun Carriage M1925E, mounted the 37-mm Gun M1925E which fired ammunition with higher powder pressures than the M1925E3, had a muzzle velocity of 2,000 feet per second, and a range of 5,400 yards. A modification of Carriage M925E, in which the recoil mechanism was changed, and the handwheels were increased in size and strength, became 37-mm Gun Carriage M1925E1, later standardized as 37-mm Gun Carriage M1.

Modified versions of the Gun M1925E and of the M1 carriage were built, including such models as the M2E1 Gun on Carriage M1E1, and the M2A1 Gun on Carriage M2. These guns were both heavier than their predecessor. The M2A1 Gun on Carriage M2 weighing 400 pounds, had greater traverse, and fired both high explosive and armor-piercing projectiles. Since the development of an explosive armor-piercing

shell with base detonating fuze was unsuccessful, the AP projectile for the M2 gun was a solid shot. Lack of explosive AP ammunition, and the excess weight of the gun and carriage, caused the M2 to be declared obsolete.

While emphasis had originally been placed on the use of the 37-mm gun as an infantry arm, increased recognition of the important part destined to be played by tanks gradually focused attention on its possible use as a light, mobile antitank gun. By 1937 reports on European tanks and the effectiveness of tanks in the Spanish Civil War changed the conception of the 37-mm Gun, as an accompanying infantry weapon for neutralization of enemy machine guns, to that of an antitank gun with which to counter the growing menace of armored forces. But it was recognized that for a 37-mm gun to be successful against tanks it must have a much higher muzzle velocity, flatter trajectory, longer range, and greater armor penetration than any previous gun of the same caliber.

Approval for the manufacture of a new gun and carriage was secured, and pilots were made during the latter part of 1937. The T3 Gun and Carriage T1 were built and tested at Aberdeen Proving Ground in February and March, 1938. These tests demonstrated that the carriage was unstable because the counterrecoil system allowed the carriage to roll forward on the wheels during firing. It was also observed that there was uncontrollable void in the recoil mechanism and that it was impossible to add oil to the system during rapid firing at high elevation. One gun was reported as showing blemishes in the bore after 76 rounds had been fired, indicating flaking of the metal. The ammunition used proved unsatisfactory, as the cartridge cases

were made of brass so soft that they were deformed abnormally during firing, and had to be removed by rammer after the breech block had been rotated with difficulty. The breech mechanism did not function satisfactorily because of improper action of the firing mechanism, and the extractor action was sluggish.

As a consequence of these defects it was decided to construct a heavier Nordenfeldt type breechblock and a sliding semi-automatic type breechblock, together with new breechrings to accommodate the mechanisms. A new recoil and counterrecoil mechanism was also designed to enable the gun crew to fill the cylinder with oil and adjust the void during rapid firing, as well as to prevent over-recoil at maximum elevation. The spades and folding trails were enlarged to increase stability during firing.

The T3 Gun modified to use the semi-automatic breechblock, opening during recoil, was designated 37-mm Gun T7, while that in which the breechblock opened during counter-recoil was designated 37-mm Gun T7E1. The gun on which the heavier Nordenfeldt breechblock was installed became the T8.

Another gun, the T10, was to be built with a hand operated, vertical sliding breechblock. A modified T1 carriage, known as 37-mm Gun Carriage T1E1, had the elevating handwheel and sight on the right side to provide for training the gun by two men on a rapidly moving target. This modification was to be compared with the basic new carriage, T1, which provided for only one-man training.

The T3 was an experimental carriage, designed but not built, which provided an extra telescope and elevating handwheel on the right side for either one or two man tracking of the target. These several

versions appeared during this period because there was violent controversy as to whether the 37-mm antitank weapon belonged to Infantry or to Field Artillery, and, in the absence of a decisive policy, the Ordnance Department had to attempt to satisfy both services. The Infantry wanted light weight and one-man control; the Field Artillery was not much concerned about weight and wanted two-man control.

At an Aberdeen Proving Ground conference instigated by the Ordnance Department in the spring of 1937 representatives of all interested agencies were brought together. The outcome of much discussion was that the weapon would be chiefly for the Infantry and that their characteristics would govern. At this same conference the then new Rheinmetal German 37-mm antitank gun was displayed. The decision was reached that our 37-mm antitank materiel would copy that design, particularly the 1.1-power straight telescope. This was the origin of the 1.1-power telescope which has since come into wide use, especially with antiaircraft guns.

A new carriage, 37-mm Gun Carriage T5, was designed and constructed to embody all the sound features of carriage T1, together with the modifications recommended for the correction of faults discovered in the T1. In general, the characteristics of carriages T1 and T5 were the same. The T5 was standardized as 37-mm Gun Carriage M4 after a slight modification of the lunette, provision for a stronger latch, and a change in the firing mechanism. The 37-mm Gun T10, Telescope T6, and Telescope Mount T26 were also standardized as 37-mm Gun M3, Telescope M6 and Telescope Mount M19, for use with the M4 carriage.

Difficulties were experienced with the wheel segments, ~~used to raise the gun off the wheels for firing position in~~ giving the weapon when they were used to raise the gun off the wheels and give it a firm base from which to fire ~~a firm base~~. Trouble in alining the wheel segment plunger with the

wheel segment plunger holes, and interference with the shield, made it advisable to add wheel segment plunger tracks and sets of plates operating as cammed surfaces to bring the plunger to the top of the plunger holes.

Experiments were conducted to determine the effect of chromium plating on the bore of the M3 gun. Indications were that such treatment would substantially increase the life and accuracy of the gun. Firing records for three of the six chrome-plated tubes tested in August and September 1944 indicated the following: One tube, thin walled and plated with 0.006 in. industrial chromium, showed no velocity drop after 320 rounds. Another tube with 0.010 in. industrial chromium plating lost no velocity until 910 rounds had been fired. A third tube with 0.008 in. plating showed no velocity drop until 910 rounds had been fired. Final reports await the completion of prolonged firing tests on all six chrome plated guns.

In November Aberdeen Proving Ground reported on tests made with coppered tubes from 37-mm Guns M3 and M3A1, which had been fired extensively and returned for examination of the copper deposit found in the grooves of the rifling. The metal-fouled bore had no apparent effect on velocity or accuracy dispersions, but the tube, which was decoppered and then tested, had a lower mean velocity attributed to the effect of the decoppering agent on powder combustion, or greater erosion apparently caused by the decoppering agent. As a result of this investigation, an order was issued to using services not to attempt decoppering of 37-mm tubes in the field.

The original powder pressure of the M3 gun was computed as 36,000 pounds per square inch. The development of new armor piercing ammunition

increased the pressure to 50,000 pounds per square inch, the muzzle velocity to 2,900 feet per second, and the maximum range to 12,850 yards.

The fact that a gun as small as the 37-mm M3 could be destructive to tanks was in large measure due to the ammunition which it fired. Projectile weight was increased from 1.25 pounds to 1.61 pounds in the case of the high explosive shell, and to 1.92 pounds for the AP and APC projectiles. The high powder pressure obtained with the ammunition developed for this gun, combined with the ballistic properties of the projectile, resulted in the high velocity and long range that enabled the M51B2 APC shell to pierce 2.4 inches of homogeneous armor plate at an angle of 20° from normal at 500 yards, and 1.6 inches of such plate at 2,000 yards.

GAS DEFLECTORS

In an attempt to hide the flash and prevent the dust cloud which normally occured during firing, it was considered advisable to equip the M3 Gun with a gas deflector. The deflector chosen was of the Solothurn type and weighed five pounds. It had no appreciable effect on the flashlessness of FNH powder used in the standard AP ammunition, but did require that the diameter of the deflector be reduced from 3.375 inches to 3.125 inches making it unnecessary to remove it from the gun to assemble the nut and set screw locking it to the muzzle of the tube. The gas deflector was to be standard equipment on all M3 guns in service or to be built, and the designation of the M3 gun with the deflector was changed to 37-mm Gun M3A1. Though these gas deflectors also acted as a muzzle brake and reduced the length of recoil by nearly one-third, they were subsequently removed, because it was not possible

to use cannister with them, formation of a dust cloud could not be fully prevented, and the personnel and instruments were not sufficiently protected from the muzzle blast of guns mounted in vehicles. All 37-mm antitank guns threaded to receive gas deflectors were designated as M3A1.

Another muzzle brake, the Hughes Recoil Control, was tested on the 37-mm Gun M3A1 at Aberdeen in 1942. While it reduced recoil 15 per cent more than the Solothurn type deflector, it was excessively heavy (31.25 pounds) and prevented normal operation of the elevating and traversing mechanism. It was also felt to be too complicated in construction, and deflected gases and muzzle blast rearward with such force as to upset the action of the gun crew.

IMPROVED 37-MM M4 CARRIAGE

In the M4 carriage, traverse was affected by use of a handwheel, although a traversing release handle allowed rapid changes of traverse through free movement of the gun. The handle had to be held in position during free traverse, for if it was released the gun was automatically locked to the traversing mechanism. It was therefore decided to modify the system and provide a new type of shoulder guard which would permit the gunner, when the free traversing clutch was disengaged, to traverse the weapon by pushing or pulling the shoulder guard with his right arm and shoulder while his right hand fingers engaged a new lever to trip the trigger. The M4 carriage, when so modified, was given the designation 37-mm Carriage, M4A1, which is the present standard 37-mm antitank gun carriage of the United States Army.

At the instigation of the Commanding Officer of Camp Blanding,

Florida, pilot models were constructed and tested to determine the feasibility of carrying ten rounds of ammunition on each trail of the 37-mm carriage. Since weight, rather than bulk, governed the amount that could be transported by the prime mover, and practically the entire weight reaction of the additional ammunition carried would be supported on the prime mover, it was decided that no increase in ammunition carrying capacity could be expected; therefore the proposed method of ammunition transport was abandoned.

Beginning with M4A1 Carriage Number 2221, the next 299 carriages were equipped with silicon manganese counterrecoil springs furnished by Watertown Arsenal, to utilize high stress steel and reduce the weight of the springs. These proved satisfactory and were continued.

In October, 1942, at the request of the Airborne Command, Army Ground Forces, work was started on modification of a 37-mm M4 Carriage to equip it with removable trails for airborne use. Removable trail hinge pins were to permit both trails to be removed and reassembled rapidly. When tested the pins were found unsatisfactory because the yokes of the trails spread and the pins were sometimes difficult to remove and install. A ratchet type hinge pin was more successful, but assembly took 1 3/4 minutes instead of the 20 seconds desired; also, it was found that the shoulder guard was likely to be damaged when the gun was dropped without trails. The Ground Forces finally decided in June 1943 that they had no need for this development and the project was canceled.

All-steel wheels for the 37-mm carriage were made and delivered to Aberdeen Proving Ground for test in March 1943. It was hoped that they would be an adequate and inexpensive substitute for combat tires for emergency use. In the first test a hub broke, and the shield and

carriage were loosened after a run of 87 miles. Further tests in June and July were unsatisfactory, as the carriage parts and shield were shaken loose, the wheels developed a negative camber, a hub broke, and excessive play developed in the traversing mechanism. Despite these mishaps it was decided to continue with further tests. Additional hard surface and secondary road tests were made along with firing tests during the remainder of the year, resulting in generally unsatisfactory performance. The project was canceled in favor of continued development and procurement of 6.00 x 16 combat tires.

The application of combat tires to 37-mm M4 carriages was approved in March 1942. Infantry, Cavalry, Desert Warfare, and Field Artillery Board tests were made. One pair of tires under test by the Field Artillery Board showed no ill effects and very little wear after operating nearly 1,000 miles in a deflated condition. After favorable tests by interested services the Ordnance Committee recommended procurement of 6.00 x 16 combat tires as standard equipment for 37-mm M4 and M4A1 carriages, and the procurement of commercial 6.00 x 16, 6-ply tires for training operations in this country. Development was concluded by this action in November 1943.

Development of improved shields for the 37-mm Gun Carriages M4 and M4A1 was recommended 4 May 1944. The shield and apron originally furnished with this weapon were small, but afforded reasonable protection to both gunner and No. 1 cannoneer if they fired from a kneeling or prone position. Quarter-inch, face hardened armor plate, set approximately vertical on the carriage, presented a flat frontal surface and a desirably low silhouette. However, when a request came from the Southwest Pacific Theatre of Operations for an improved shield, drawings of the shield designed and built in the field by the Marine Corps were obtained.

Two pilots were manufactured incorporating the suggested changes, which increased the weight of the shield by 165 pounds but provided greater protection to gun and crew. The first pilot was shipped to the Marine Corps Equipment Board in December 1944, and the second held at Aberdeen Proving Ground pending results of service board tests. Because of the diminishing importance of the 37-mm antitank gun the project was not considered highly essential, and was canceled by Ordnance Committee action in April 1945.

JUNGLE WARFARE GUN

Difficulties of transportation in jungle areas where heavy tropical vegetation and lack of roads require that weapons be manpacked to firing positions, resulted in development of the 37-mm Gun, T32, on Tripod Mount T9. Since portability was more important than range for a gun used in jungle warfare, muzzle velocity could be reduced and the gun made lighter. It was felt that a 37-mm gun of light weight and low velocity would fulfill the need for a weapon capable of manual transport and greater fire power than that possessed by small arms.

The project to develop a 37-mm gun of the desired type was initiated 1 September 1943. Given the designation 37-mm Gun T31, it was to use the same powder chamber as in 37-mm Gun M3, with a maximum pressure of 27,000 pounds per square inch. The rifling was to have a twist of 1 in 25. A second gun, the T31E1, was identical to the T31, except that the T31E1 had a rifling twist of 1 in 22. Two additional guns, T31E2 and T31E3, were also constructed with chambers similar to that of the M4, but with rifling twists of 1 in 25 and 1 in 22. Work on these experimental models was discontinued in December 1943, when the T31E2 was redesignated T32 and

changed in the following manner.

The T32 employed a shortened M3 tube and retained the M3 breech mechanism. The breech ring was furnished with interrupted threads for quick assembly and disassembly in the field, and carried a spring-locking device on its upper surface. The gun tube was secured to the sleigh by a key which fitted in a keyway in the tube. With the key in position in the keyway, snap locks on the sleigh fastened the tube in place.

The sleigh was fitted to the cradle in the same manner as that of the 37-mm Gun Carriage M4, and the cradle was fixed to the tripod mount by a small top carriage. To obtain a lighter recoil mechanism than that of the standard 37-mm antitank gun, the recoil mechanism of the M4 carriage was shortened for use with the T32 gun.

The Tripod Mount T9, was the Cal..50, Machine Gun Tripod, M3, with a modified traversing and elevating mechanism on the traversing bar between the rear legs of the mount. This mount was not as stable as desired unless a sand bag was placed over the front leg. Gun and mount could be broken down into five separate loads for manual transport. These loads were composed of the gun tube, the breech ring with breech mechanism, the recoil mechanism and cradle, the sleigh, and the tripod mount. No load weighed more than 67½ pounds.

The M6 Telescope was selected as sighting equipment for the T32 Gun. A telescope mount, with a horizontal adjustment similar to that of the M19 Mount and a vertical adjustment consisting of a worm gear clamped by a locking nut, was secured to the cradle. In September 1944 this equipment was replaced with the newly developed Telescope T126 (later modified to T126E1), Telescope Mount T103, and Instrument Light M36, which were to be supplied for limited procurement with the weapon.

Ammunition consisted of 37-mm HE Shell M63, with BD Fuze M58, fixed to 37-mm Cartridge Case Mk. IIIA2, and Canister M2. Propellent charges for both rounds were modified to suit the characteristics of the T32 Gun, a velocity of 1,500 feet per second for the HE, M63 being considered the maximum allowable with the tripod mount.

Although test firing of the T32 pilot model had not been completed at Aberdeen Proving Ground, 200 guns were under production in November 1943. Preliminary reports of partial tests indicated that the performance of the gun was satisfactory.

In January 1944 a pilot was under test at Rock Island Arsenal, where designs for paracrates were being made. Additional units were to be sent to the Airborne Command and the Mountain and Winter Warfare Board for service tests. In addition to the 200 originally ordered, 20 units were to be procured for further engineering tests, and a pilot sent to the Infantry Board for service tests.

Meanwhile the T32 gun had been recommended for limited procurement, and another 200 guns and mounts were ordered in April. As various service tests progressed and reports from the field were received, the satisfactory performance of the gun became more evident. Limited Procurement was extended to 500 weapons, while plans and drawings were proposed for a similar 37-mm gun which might be used by paratroops in jungle warfare and for mountain and amphibious operations.

Lighter in weight and easily dismantled or assembled without tools, the proposed jungle gun was more suitable for pack loads. The weight of the tube was reduced from 58 pounds to 43 pounds, and that of the breech mechanism from 52 to 32 pounds, by reducing the muzzle velocity to 1,500 feet per second and the rated maximum chamber pressure to 20,000 pounds

per square inch. This loss in firepower in no way limited the effectiveness of the weapon in jungle areas, and the ~~less~~ reduction in weight was a distinct advantage in mobility and portability. The designation T33 was given this final experimental model.

Having the chamber of the 37-mm Gun M4, and the M4 tube (reduced 15 inches in length), the T33 is equipped with a breechblock which can be readily mounted for either drop block or side sliding. After eight pilots had been completed at Watervliet Arsenal and shipped to Aberdeen Proving Ground, preliminary tests showed that interrupting the breech ring threads would speed assembly and disassembly of the gun. When modified according to this recommendation ~~they were~~ the gun was designated T33E1.

Mount T10 for the T33 gun, unlike the modified machine gun tripod mount (T9) for the T32 gun ~~which did not provide adequate stability~~, was a pedestal mount with split telescoping trails. It was heavier (180 pounds) than the T9 (60.5 pounds), but use of light weight metals and refinement of design were expected to reduce the weight approximately 18 pounds so that the T33 gun and T10 mount in the final design were expected to weigh approximately 237.50 pounds when compared to the 265.25 pound weight of the T32 gun and Mount T9. The distribution of weight amongst the individual pack loads was better in the T10 type than in the T9 type mount.

In April 1944 two pilots were under manufacture for a modified mount T10E1 which had small rubber-tired wheels. They underwent test at Aberdeen in May, and minor changes and improvements resulting from firing tests were to be incorporated in a further modification of the mount, T10E2. As the development work progressed, the wheeled mount was discontinued because no advantage could be seen in its use ~~and work reverted to the original T10 pedestal type with trails~~.

The mount could be locked in traverse at any point in the 45° arc

of traverse. Provision was then made for a vernier adjustment of approximately 10 degrees traverse. The trails, as originally designed, were approximately seven feet long and telescoped to approximately four feet in length. Infantry Board tests held at Fort Benning have resulted in a further reduction of weight by considerably shortening the length of the trails, at the expense of greater mount hgt.

The final mount was designated T10E3 and was satisfactorily tested at Aberdeen Proving Ground in December 1944. Pilots were shipped to the Infantry Board, Cavalry Board, and Airborne Command for extended service tests early in 1945.

The recoil mechanism T38 was to be used with the 37-mm Gun T33, as a substitute for the 37-mm M1916 materiel. At the time this specification was made, the plan was to use the T33 also as a subcaliber gun. Future use as an external subcaliber gun was considered in its design, which includes provision for a simple mount for the parent gun. Subcaliber fittings were manufactured to make it adaptable to the 75-mm M1 and M2 guns as inbore subcaliber weapons. However, development of the T33 as a subcaliber weapon was canceled in July 1944, as it became far more essential to consider its special purpose as a light infantry pack weapon.

Experimental pilots were developed to test the practicability of using aluminum and magnesium extruded shapes for the recoil mechanism, in a further effort to reduce the weight of the gun. These models were designated T38E2, E3, E4, and E5. Results of ~~them~~ 2000 round tests indicated ~~were not available in January of 1945.~~ the T38E5 mechanism, having magnesium cylinders and integral recoil slides was equally satisfactory to the other types, and was appreciably lighter in weight.

Sighting equipment for Gun T33 and Mount T10, consists of the 3-power, direct fife Telescope T126E1, and Telescope Mount T103, with

illuminated reticule graduated with standard pattern up to 2,400 yards.

REFERENCES

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TM 9-246, "37-mm Gun T32 and Tripod Mount T9," 10 August 1944.

FM 23-70, "Basic Field Manual, 37-mm Gun, Antitank, M3," War Department, Washington, 1942.

OCM 13348, 14 January 1937, recommends development of a 37-mm Antitank Gun.

OCM 13473, 25 February 1937, records military characteristics for 37-mm Antitank Guns and Ammunition. Approved by OCM 13581, 1 April 1937.

OCM 13665, 14 May 1937, discusses program for tests of Antitank Guns May 18-21, 1937 at Aberdeen Proving Ground.

OCM 13889, 9 September 1937, approves manufacture of pilot models of 37-mm Gun Carriage T1, Telescope T6, and Telescope Mount T23.

OCM 14342, 24 February 1938, approves T.S.T.P. 1938-731 for development of tests of 37-mm Guns T3 and 37-mm Carriage T1.

OCM 14422, 7 April 1938, requires action to improve functioning of materiel and practice ammunition on antitank gun projects.

OCM 14495, 19 May 1938, recommends manufacture of 2 pilot 37-mm Guns T7.

OCM 14511, 26 May 1938, recommends manufacture of pilot 37-mm Gun T8.

OCM 14572, 14 July 1938, reports on 37-mm Gun development, including Guns T3, T7, T7E1, T8 & T10, Carriages T1E2 and T1E3.

OCM 14762, 27 October 1938, recommends standardization of 37-mm Gun T7, as M3; 37-mm Gun Carriage T5 as M4; Telescope T6 as M6, and Telescope Mount T26 as M19. Aso recommends that 37-mm Gun M3 be mounted in Medium Tank M2. Approved by OCM 14824, 15 December 1938.

OCM 14776, 10 November 1938, approves First Addendum to Technical Staff Test Program 1938-731 for 37-mm Gun T7E2 and Carriage T5.

OCM 14794, 25 November 1938, recommends standardization of 37-mm Gun T10 as M3 instead of 37-mm Gun T7, recommended for standardization in OCM 14762, 27 October 1938. Approved by OCM 14824, 15 December 1938.

OCM 15273, 17 August 1939, approves further development of breech mechanism for 37-mm Gun T7, to open and close automatically.

OCM 16098, 19 September 1940, reports on test of 37-mm Breech Mechanism M5E1.

OCM 16693, 18 May 1941, recommends means for correcting difficulties encountered in operating of wheel segments.

OCM 17026, 24 July 1941, states that rated pressure of Gun M3 should be 40,000 pounds per square inch when taken with new internal pressure gages M1, or radial pressure gages.

OCM 17633, 1 January 1942, approves changes in method of traversing 37-mm Gun Carriage M4 and firing the piece. Also recommends that M4 Carriage with these modifications be designated 37-mm Gun Carriage M4A1. Approved by OCM 17713, 29 January 1942.

OCM 17821, 19 February 1942, recommends approval of project to apply gas deflectors to all guns on 37-mm Carriages M4 and M4A1, guns so equipped to be designated 37-mm Gun M3A1. Approved by OCM 17888, 5 March 1942.

OCM 17843, 26 February 1942, recommends application of wheel segment modifications to all completed M4 Carriages when practicable.

OCM 17910, 12 March 1942, approves application of 6.00 x 16 combat tires and new wheel hubs to 37-mm Gun Carriages M4 and M4A1.

OCM 18645, 20 August 1942, reports test of blackout lights for 37-mm Gun M3 and Carriage M4A1, and recommends development be dropped.

OCM 18646, 20 August 1942, rejects experimental method for transporting ammunition on trails of 37-mm Carriage M4A1.

OCM 18951, 1 October 1942, initiated project to test restrictor rings for 37-MM Gun Carriage M4A1.

OCM 19135, 5 November 1942, directs test by Cavalry Board of gas deflectors for 37-mm Gun M3A1 and Carriage M4A1.

OCM 19174, 12 November 1942, directs Service Board test of M3A1 guns equipped with gas deflectors.

OCM 19191, 19 November 1942, reports unsatisfactory test of Hughes Recoil Control on Gun M3A1.

OCM 19617, 28 January 1943, cancels project to apply gas deflector to 37-mm Guns M1A2, M3, M5 and M6, due to issuing canister.

OCM 20496, 20 May 1943, directs that all 37-mm M4 Carriages be converted to M4A1 status.

OCM 20498, 20 May 1943, approves development of new type of gas deflector for 37-mm Guns M3A1 and M6 not adversely affected by cannister.

OCM 21354, 19 August 1943, approves cancellation of removable hinge pins for trails of 37-mm Gun Carriage M4.

OCM 22162, 25 November 1943, reports test of 37-mm Gun Carriage M4A1 by Infantry, Cavalry, and Field Artillery Boards.

OCM 22500, 30 December 1943, recommends 37-mm Gun T32 and 37-mm Gun Mount T9 as required, limited procurement types. Approved by OCM 22677, 20 January 1944.

OCM 23605, 27 April 1943, 37-mm Gun T32, 37-mm Gun Mount T9, procurement of 200 in addition to the 200 procured as indicated in Item 22677.

OCM 23691, 4 May 1944, recommends development of improved shields for 37-mm Gun Carriage M4 and M4A1. Approved by OCM 23862, 18 May 1944.

OCM 24312, 6 July 1944, recommends development of Recoil Mechanism T38 for 37-mm Gun T33 and 37-mm Gun Mount T10.

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O.O. 472.1/1640 (C.I. 472.5/9576-B), 17 June 1938, (and 7 Indorsements), Infantry Board to Chief of Infantry discusses test report and standardization of 37-mm Antitank materiel.

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O.O. 4721./82, 1 August 1940, Aberdeen Proving Ground to Office, Chief of Ordnance discusses results of conference concerning 37-mm M1A2 guns and M3 carriages.

O.O. 472.1/2606, 2 September 1941, recommends new shoulder guard to permit ease of free traverse in 37-mm Gun M3 and indicates various points of design desired.

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Field Artillery Board O-18-F, "First Partial Report of Test 37-mm Gun T3 and 37-mm Gun Carriage T1," 14 June 1938

Infantry Board Report, No. 1010, "Test of 37-mm T3 Gun and Gun Carriage T1," 17 June 1938.

Infantry Board Report No. 1213, "Improvement of 37-mm Gun M3 and Carriage M4," 1 May 1942.

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37-MM GUN M1916 (French)

Gun

Caliber	37-mm
Length	19.94 calibers
Weight	104 lb.
Rifling, uniform left hand	1 turn in 30 calibers
Breech mechanism	Nordenfeldt type
Maximum powder pressure	18,000 lb./sq. in.
Maximum range, low explosive shell	4,000 yd.
high explosive shell	4,200 yd.
Muzzle velocity, ..low explosive shell	1,204 ft./sec.
high explosive shell	4,200 yd.
Weight of high explosive shell	1.234 lb.

Recoil Mechanism

Type	Hydrospring
Length of recoil	7 to 10 in.

Mount

Length, overall	75 in.
Width, overall, ..trails spread	57 in.
Weight of gun on tripod mount	188 lb.
trails, complete tripod mt	84 lb.
wheels and axle	172 lb.
Elevation (screw type)	-14° to +20°
Traverse (screw type)	38°

37-MM GUN 1923E

Caliber.....37-mm

Length.....30.5 calibers

Weight of gun unit.....82 lb.

Maximum range.....5,300 yd.

Muzzle velocity.....2,000 ft./sec.

Weight of shell.....1.25 lb.

Elevation.....-5° to +20°

Traverse.....5°

Weight of recoil system.....84 lb.

Weight of wheels and axle.....86 lb.

Weight of trail, handle, and lock.....109 lb.

37-MM GUN M1925E

Caliber.....37-mm

Length.....32.75 cal. (47.68 in.)

Weight of gun unit.....77 lb.

Weight of shell.....1.25 lb.

Maximum range.....5,600 yd.

Muzzle velocity.....2,000 ft./sec.

Total weight of unit.....357 lb.

Weight of recoil system and sight.....82 lb.

Weight of wheels and axles.....114 lb.

Weight of trail.....82 lb.

Elevation.....-14° to +21°

Traverse.....38°

37-MM Antitank Gun M3A1 and Carriage M4A1

Gun

Weight	191 lb.
Length (overall) of gun	6 ft. 10.5 in.
Length of bore	53.5 cal.
Travel of projectile in bore	69.95 in.
Volume of chamber	19.92 cu. in.
Maximum powder pressure	50,000 lb./sq. in.
Type of breech mechanism	Drop block
Range	12,850 yd.
Muzzle velocity	2,900 ft./sec.
Rate of fire (approximate)	25 rd./min.

Recoil Mechanism

Type	Hydrospring
Weight	77.5 lb.
Normal recoil	17 to 20 in.
Maximum recoil	20.5 in.
Spring pressure (average)	217 lb.
Maximum piston rod pull	2400 lb.

Carriage

Length of carriage from muzzle to lunette	154.5 in.
Total weight without gun	721 lb.
Height of lunette (limbered position)	29.5 in.
Height (traveling position)	37.875 in.
Width over hub caps	63.5 in.
Trail spread (maximum), included angle	60°
Elevation	-10° to 15°
Traverse	30° right and left

Gun, 37-MM, T32 and Mount, Tripod, T9

Caliber	37-mm
Length of tube	50 in.
Weight of tube	58 lb.
Weight of breech ring and breech mechanism	52 in.
Weight of recoil mechanism and cradle	67.5 lb.
Weight of sleigh	28 lb.
Weight of tripod	51 lb.
Total weight of gun and mount	256.5 lb.
Recoil mechanism	Hydrospring
Breech mechanism	Vertical drop block
Elevation	-5° to 12°
Traverse, with traversing bar	800 mils
Traverse, without traversing bar	6,400 mils
Muzzle velocity (Shell, HE, M63)	1,500 ft./sec.
Range, 90.9 mils elevation (Shell, HE, M63)	2,500 yd.
Computed Maximum range (Shell, HE, M63)	7,750 yd.

37-MM Gun T33 and 37-MM Mount T10

Weight.....75 lb.

Breechblock (not semiautomatic).....Hand operated
The gun may be mounted so that the breechblock is either horizontal or vertical

Rifling.....1 turn in 25 cal.

Rated maximum pressure.....20,000 lb./sq. in.

Muzzle velocity (Shell, HE, M63).....1500 ft./sec.

Recoil mechanism.....T38

Length of recoil, normal.....12 in.

Length of recoil, maximum.....13.25 in.

Type firing.....Base with trails

Traverse, free total.....45°
Vernier adjustment (approx.).....10°

Elevation (screw type).....-5° to +18°

Ammunition, Shell, HE, M63, M54, Canister, M2 Shot, AP, M80 Practice

37-mm Gun Carriage M1916, rear view
(mounted on Artillery Wheels) TD 688

37-mm M1916 Gun, with carriage as
modified by the Cavalry Board TD 693

37-mm Gun Carriage M1923E

TD 420

37-mm Gun Carriage M1925E

TD 713

TD 2172

37-mm Gun T31 on Mount T9

37-mm Gun T32 on Mount T9

TD 2731

TD 3003

37-mm Gun T33, Mount T10, Recoil Mechanism T38 (trails retracted)

37-mm Gun T33E1, on Mount T10E3, Recoil Mechanism T38E1, with trails extended

TD 5137

37-mm Gun Carriage M1

TD 715.

37-mm Gun Carriage M1E1
with 37-mm Gun M2E1

TD 696

37-mm Gun M2A1 on
37-mm Gun Carriage M2

TD 443

TD 441

37-mm Gun Carriage T1

TD 4036

37-mm Gun Carriage M4A1, firing position

TD 1250

37-mm antitank gun M3A1

1. Elevating handwheel
2. Traversing knob
3. Traversing release lock
4. Firing lever
5. Shoulder traversing bar

TD 1229

37-mm Gun M3A1 on M4A1 Carriage
left side view

TD 4000

37-mm Gun M3A1 and Carriage M4A1
left front, firing position, note firing segments

FM 254

37-mm Japanese antitank gun (used to 1937)

FM 87

3.7-cm. Pak German antitank gun

British 2.244-inch antitank gun (6 Pounder)

By direction of the Chief of Ordnance, at an Ordnance Subcommittee meeting 14 February 1941 action was taken to prepare drawings of the British 2.244-inch antitank gun. Although at that time there was no requirement for this materiel for the United States Army, it was probable that these guns would be manufactured in this country for the British. In preparing the drawings American dimensions, tolerances, threads, and gears were used. But the rifling, steels, and armor plate specifications were to correspond as closely as possible with those of Great Britain. Two pilots were to be procured by the Industrial Service and two sample units together with 100 rounds of ammunition were to be sent from England. By close comparison during the drawing and manufacture of pilot models important components could be guaranteed interchangeable, whether they were of British or American manufacture. Ammunition, assembled guns, tipping parts (with change of mating elevating mechanism parts if necessary), complete top carriages, complete bottom carriages, complete trails, shields, on-carriage fire control units, and complete wheels were all interchangeable components.

A separate report was to be prepared on the design development and tests of suitable ammunition which might be manufactured in the United States for this weapon, and for tests of the two units to be made in this country.

Several months later the 6-pounder was classified Substitute Standard materiel and redesignated 57-mm Gun M1, together with the 57-mm Gun Carriage M1, Telescope M18 and Telescope Mount M24. The

pilots were expected to be completed by 1 September 1941 for test at Aberdeen Proving Ground. Tests of a British 2.244-inch model were held at Aberdeen late in the spring and in the early part of the summer. The carriage was found unstable because of a large powder couple which acted on the recoiling parts during the powder period. The couple was of appreciable magnitude because the center of gravity of the recoiling parts was located at too great a distance below the bore of the gun. To correct this difficulty a shift of the center of gravity was attempted by adding a counterweight so that balance of the tipping parts about the trunnion was disturbed. While tests showed that the counterweight decreased the instability to a certain extent, and lessened the hop of the carriage, it did not eliminate the bouncing and vibration, which persisted during the whole of the recoil-counterrecoil cycle.

Other difficulties revealed by the tests tended to decrease the rate of fire. Empty cartridge cases were not ejected until the gun had nearly returned to battery. In closing, the breechblock knocked the gun off the line of sight, preventing accurate sighting on the target until after the gun was loaded. The loading, aiming, and firing period could not begin until the recoil-counterrecoil period had ended. Furthermore, no time advantage was gained by using the counterweight, since the time of loading, aiming, and firing exceeded the bouncing and vibrating period of the weapon with or without the counterweight. The rate of fire was found to be 15 rounds per minute or four seconds per round. The average period required to load, aim, and fire was approximately three seconds. The counterweight project was abandoned because of its comparative ineffectiveness. (Later design improvements in American 57-mm materiel overcame these

difficulties by other means.)

British experience showed the 37-mm antitank gun was ineffective against German tanks, therefore efforts of both Great Britain and this country were directed toward making the 57-mm antitank gun more effective. Lend-lease requirements for these weapons, determined in December 1942, were 433 in 1942, 5,800 in 1943, and 10,000 (accumulative) by the end of 1944.

Characteristics for the 6-pounder (M1) originally specified the following velocity levels and pressure limit:

Projectile, APC, 57-mm, M86 - 2700 ft./sec. - 46,000 lb./sq. in.
Shot, AP, 57-mm, M70 - 2800 ft./sec. - 46,000 lb./sq. in.

But the British proposed increasing the velocity of the M70 Shot to 3,000 feet per second, with a corresponding pressure of 50,000 pounds per square inch. The pressure requirement was lowered late in 1942 to 46,000 pounds but the muzzle velocity was held at 3,000 feet per second. No difficulty was encountered obtaining suitable powder for this velocity, but there was trouble in the extraction of the cartridge cases. In the spring of 1943 proof pressures were run as high as 51,400 pounds per square inch (112% of the specified 46,000 level) when Aberdeen Proving Ground reported that failures to extract began at 46,000 pounds per square inch and became more numerous at higher pressures. In most instances the cartridge case which failed to extract showed practically no extractor marks on the under side of the flange. Cases which were stuck could be loosened with a very light tap of the rammer, which indicated that the extraction mechanism of the gun was weak and at fault.

A conference at the beginning of February 1943 in the Ordnance Office reemphasized the need for increased striking power in the 57-mm guns to be manufactured for the British, even though stuck cartridges would

occasionally result. A compromise was reached in which the M70 Shot was to have a velocity of 2,950 feet per second, with a rated maximum pressure of 44,000 pounds per square inch. This pressure was recommended as fixed standard for 57-mm M1 guns, while the 6.28 lb. AP Shot (M70) was to have a velocity of 2,950 feet per second. The APC Shot M86 was to have a weight of 7.3 pounds loaded and fuzed and a velocity of 2,700 feet per second. Firing tables were prepared on the basis of these velocities.

M1 Carriage Series - M1A1, M1A2, M1A3

When the M1 carriage was equipped with combat tires and wheels with divided rims instead of the standard type it was differentiated from M1 carriages by the designation M1A1. Both carriages were modified to provide free traverse instead of gear traverse at a request from the Inspector General's Representative Inspection Board of the United Kingdom and Canada at the beginning of June 1942. The traversing arc and gear assembly were omitted from new design drawings and an arm was added to control the movement of the top carriage. The question of omitting the wheel segments came up at this time but the decision depended on the outcome of tests not then completed. The new model carriage was to be called the M1A2, and again to be manufactured only for British use. However, the Ordnance drawings copied from British specifications and drawings carried the classification of Substitute Standard equipment and the M1A1 Gun Carriage a listing as Limited Standard. All 57-mm gun carriages delivered after 1 September 1942 were equipped with the free traversing arm (M1A2 type).

In July 1943 arrangements were made for tests of 57-mm materiel by Armored Force and Cavalry Boards. Test by the Tank Destroyer Board was also ordered, but canceled prior to completion on authority of the

Commanding General, AGF. Much of the materiel to be tested was never received by the board; therefore no partial report on preliminary tests was made.

Equipment for test by the Armored Force Board consisted of two 57-mm Guns M1, two M1A2 carriages, and 500 rounds of 57-mm ammunition. Test results comparing the 57-mm M1 on carriage M1A2 with 37-mm antitank materiel showed the 57-mm weapon greatly superior to the 37-mm M3 in striking power and accuracy. Firing at moving targets with the 57-mm gun, fifty percent hits were recorded at ranges from 600 to 1,000 yards. The stability of the 57-mm carriage was extremely good when on wheel segments, but on wheels the displacement was excessive. The one-power telescope was unsatisfactory and was subsequently replaced by the three-power M69C and mount M63. About 1,400 pounds heavier than the 37-mm Gun M3 towed carriages, the 57-mm Gun M1 on carriage M1A2 presented a manhandling problem, as a crew of five was required to maneuver the gun into firing position. Under difficult conditions the available manpower should not be below eight. The shoulder traverse was undesirable, and the mechanical hand traverse provided in original design was poorly positioned. Rate of fire was not determined, as 13 seconds elapsed between rounds because of dust raised by the muzzle blast which obscured the target.

At this point it might be interesting to consider General Patton's opinion as the relative usefulness of 57-mm vs. 37-mm antitank weapons, as it appeared in Seventh Army Notes on the Sicilian Campaign:

"If a projectile can be developed for the 37-mm with more penetrating effect, it is superior to the 57-mm as an offensive antitank weapon,.....it can be pulled by the low-relief ¼-ton truck, the 57-mm cannot and must be towed either by a half-track or a high-relief 3/4 ton

truck. Second, with the limited crews available, the 57-mm cannot be manhandled any distance over bad country while the 37-mm can. Even with present ammunition the 37-mm is deadly against tanks up to 400 yards." (Lt. General G.S. Patton, Jr.)

Thus, while the improved striking power of the 57-mm antitank gun was desirable, the M1A2 modification of the British carriage did not offer an ideal or final solution. The Armored Board recommended that the 57-mm Gun M1 on Carriage M1A2 be considered an acceptable substitute for a more powerful and satisfactory towed antitank gun until such a weapon became available. The Board recommended that the development for improved 76-mm antitank guns be expedited, and that antitank gun sections be provided with mats to aid in controlling the muzzle blast dust cloud. This indicates that the Armored Force Board and the Ordnance Research and Development Service were already thinking in terms of heavier weapons with a punch and range sufficient to meet the German "88" and did not conceive of antitank gun development as an attempt to provide infantry accompanying arms as much as they did a mobile, hard hitting, weapon of medium weight to increase the fire power of antitank units.

In June of 1943 a directive for service test by the Airborne Command was issued by the Commanding General, AGF because there was an urgent need for a light antitank weapon in airborne operations. A 57-mm M1 gun and an M1A2 carriage were shipped to Camp Mackall, Headquarters for the Airborne Command, for loading tests. The test report dated 16 August 1943 stated that the 57-mm gun could not be loaded in the cargo compartment of the CG-4A Glider because the overall length of the gun was 200.5 inches and the length of the compartment, only 158 inches. Also, the door of the glider compartment was 70 inches wide and did not permit the gun, which

was 75 inches wide, to pass through. The Airborne Command commented further that the 2700 pound weight of the gun precluded its being towed by the airborne prime movers then available.

It was possible to load the 57-mm antitank gun in the C-47 airplane. Three loadings demonstrated that the time required was 12 to 15 minutes to load and unload but that difficulties arose again because of the length of the gun. Because of the excessive size and weight, the 57-mm materiel was not considered acceptable for airborne operations.

To determine the general suitability for Cavalry employment, the Cavalry Board also tested the 57-mm gun M1 and modified M1 carriage, considering its operational characteristics, and its powers and limitations for cavalry horse and mechanized units. Again the efficiency of the 57-mm gun was tested against that of the 37-mm and a service test report was released 8 February 1944. The Cavalry Board demonstrated that the 57-mm antitank gun could knock out medium tanks or similar armor at normal combat ranges. The accuracy and ease of operation was found comparable to that of the 37-mm in engaging fixed targets, but inferior in engaging moving targets. On a gun of this caliber and weight the free traverse principle was felt by the board to be unsatisfactory. Both mobility and maneuverability were limited by the weight of the 57, which was three times that of the 37-mm gun, ~~irrespective of~~ whether the guns were towed by hand or by prime movers. Actually, the board concluded, towed guns were not desired as basic armament within mechanized cavalry units. And there was no requirement in Horse Cavalry unit operations for an antitank gun of 57-mm caliber or weight either to replace or supplement the integral 37-mm guns. As might be expected from these conclusions, the 57-mm antitank gun was not recommended as suitable to replace or supplement 37-mm materiel in cavalry ~~horse or~~

~~mechanized units.~~ operations.

Further modifications to the British type gun and carriage had qualified them for standardization and issue to United States troops.

These modifications, recommended mainly by the Infantry Board tests held in the spring of 1943, included the changing of the lunette assembly used on carriages M1, M1A1, and M1A2. The ring of the lunette did not extend back far enough to provide an adequate turning radius when the carriage was attached to the prime movers used by American Infantry Divisions, nor did the assembly provide sufficient clearance between the ground and the spade tips when the carriage was attached to standard prime movers. Substituting the lunette, drawbar, brackets and trail lock assembly from the 75-mm Gun Carriage, M2A3 or M2A2 for test, the turning and clearance difficulties were solved and sufficient strength to withstand the stresses of cross country travel was provided. This change to a trailer-type lunette made a new carriage designation necessary. The modified carriage, redesignated M1A3, was listed as standard equipment for the U.S. Army, and the M1A2 was classified Substitute Standard because that carriage was only being procured for Lend-Lease transactions, and Great Britain desired to continue the manufacture of the M1A2 without change.

To save rubber ~~the Carriage Section of the Artillery Development Branch, Technical Division, Ordnance Department developed~~ experimental restrictor rings for 7.50-16 tires on divided wheels were developed. This project included rings for 105-mm howitzer carriages as well as for the 57-mm Gun Carriage M1A3. Recommendations made by the Infantry Board after tests at Fort Benning and Aberdeen Proving Ground (Infantry Board Report No. 1509, 9 August 1943) proposed cancellation of the project with the following comment: "During tests one carriage was equipped with restrictor rings and steel

rims, the other set of wheels had rubber bead type rims. The tires and tubes failed during seventeen miles of operation in the deflated condition." The conclusion was reached that restrictor rings were not a suitable substitute for combat tires, and that they should not be considered satisfactory or suitable for military use. Cancellation was approved 4 November 1943.

57-MM Carriage M2

The detailed recommendations for improvement and change in M1A2 and M1A3 carriages proposed by the Infantry Board after exhaustive test were itemized in the test report and approval was recorded 10 February 1944 at the Ordnance Committee meeting when the designation 57-mm Gun Carriage M2 was reserved for all M1A3 carriages modified according to the new specifications.

The more important modifications recommended and approved included the following: (1) ~~Retention of the~~ Side shields were retained, though their value was purely psychological; (2) ~~the use of~~ the 75-mm Gun type drawbar assembly was to be used; (3) ~~and use of~~ the 1-ton trailer type lunette was to be employed as an expedient during training pending availability of the 75-mm gun type; (4) The caster wheel assembly, Infantry Board type, was to be used by 57-mm gun carriages for U.S. Troops; (5) ~~and~~ Infantry Board type handspike brackets and rammer staff brackets were to be included; (6) The trail handles were to be relocated in future production; ~~and~~ (7) a new utility box was adopted; (8) The .22 - .30 Subcaliber mount M14 was to be used; ~~and~~ (9) the 8.00-16 combat tires were to be retained; (10) The traversing stop assembly (B162847) was eliminated, and (11) the question of using wheel segments was to be considered at a later date.

The other modifications recommended were less significant and did

not affect the design of major components, but dealt rather with proper alining, clearances, and balancing of the piece. Classification of existing models were standardized 10 February 1944 as follows: 57-mm Gun Carriage M1A2 - Substitute Standard; 57-mm Gun Carriage M1A3 - Limited Standard; and 57-mm Gun Carriage M2 - Standard.

Elevating Mechanisms for M2 Carriages

~~The Artillery Board, Industrial Division designed~~ Brackett & Two types of elevating mechanisms were designed for the 57-mm carriages, as recommended by action of the Ordnance Technical Committee. In April 1944 model designations were assigned to the carriages which were to be provided with these experimental mechanisms for test. Adapted to the M2 carriage, either mechanism could be installed in the field if necessary. Carriage M2E1 was equipped with a screw elevating mechanism of the type shown on drawing No. D7110631, and Carriage M2E2 was equipped with the new inclosed worm and gear, spur pinion and rack type elevating mechanism shown on Ordnance drawing No. D7110681. Two carriages of each type were shipped to Aberdeen Proving Ground for proof firing, one of each remained for extended tests, and the other two were forwarded to the Infantry Board for service test.

A report on the performance of the two new elevating mechanisms as contrasted with that on the M2 carriage was issued by the Infantry Board on 31 October 1944.

The worm, pinion and rack mechanism proved most satisfactory of the three after continued operation. It showed less wear and functioned more smoothly. A disadvantge was reported in the location of the sight in relation to the elevating mechanism housing. Only 7/16 inch clearance between the rubber eyepiece and the metal of the housing was provided. This was a distinct mental and physical hazard to the gunner. The board recommended

that the sight mount be moved for greater clearance.

Little difference in comparative accuracy of the test carriages appeared. The M2E2 had less play and only slight handwheel whip. There was no apparent effect of mud, rain or dust on any carriage during towing operations. The M2 showed greatest wear from dry line manipulation, the M2E1 less, and the M2E2 carriage least. Little difference in accuracy of fire was observed when a muzzle brake was used.

Additional ~~test~~ comparative data is tabulated here:

Carriage Designation	Type of elev. mech.	Weight of Elevating Mechanism	Clearance between mech. and sight M69
M2	Rack and worm	21.5 lb.	2 3/4 in.
M2E1	Screw type	30.0 lb.	2 3/4 in.
M2E2	Rack, pinion worm wheel and worm	32.5 lb.	7/16 in.

In January 1945 the M2E2 carriage was standardized as the M2A1, and in May further reclassification established the following status: 57-mm Gun M1A1 and Carriage M2A1, Standard; 57-mm Gun M1 on M2 Carriage, Limited Standard items. The M1, M1A1 and M1A2 carriages had already been declared obsolete in November 1944, the M1 and M1A1 because they were never issued to the United States Army, and the M1A2 because all the carriages of this category were converted to M1A3 types.

It is interesting to note that 148 of the obsolete carriages declared surplus early in 1945 which were made originally for the British under Lend-Lease were rebuilt instead of junked when the British changed their requirements and the carriages were needed for American 57-mm guns. Several hundred more of these carriages are expected to be made available for rebuilding, saving $2,500 on each unit so reclaimed.

57-mm Gun T2, and Carriage T1 (American Design)

In addition to the American version of the British 6-pounder another 57-mm antitank gun was developed at the recommendation of the Artillery Division, Industrial Service. This weapon, an experimental gun and carriage similar to the 37-mm antitank gun, was designed to use British ammunition as already developed. Nomenclature assigned to the experimental model was: 57-mm Gun T2 and 57-mm Gun Carriage T1 with Telescope T19, and Telescope Mount T37. The comparative characteristics of the British 2.244-inch and the American 57-mm antitank guns appear in a table at the end of this chapter.

Preliminary discussion of an American design for a 57-mm antitank gun took place in June 1941. Four pilots were proposed, two equipped with the 75-mm pack howitzer's hydropneumatic recoil mechanism, and two with hydrospring recuperators. The following month the maximum pressure limit for the experimental weapon was set at 46,000 pounds per square inch, and maximum service pressure at 36,000 pounds. The muzzle velocity was set at 2700 feet per second. Rock Island Arsenal was to manufacture the 4 pilot carriages and expected to deliver them around 15 October 1941. The gun tubes were to be completed by Watervliet Arsenal by the end of October.

Drawings for the experimental weapons were 75% complete in September 1941. Difficulty was encountered in the machining of one gun because of its extreme hardness. A month later all detailed drawings had been released to the shop, and all patterns completed. Top carriages and trails were in process of welding; cradles were in process of machining. The four pilot carriages were not completed until December 18, and final assembly depended on receipt of guns from Watervliet and breech blocks and breech mechanisms from a private manufacturer. The pilot guns were not actually

shipped to Rock Island Arsenal ~~until~~ 28 January 1942.

Comparative firing of the T2 and M1 guns was scheduled to start 20 February at Aberdeen Proving Ground, but tests were not run until April, May and June of 1942.

Though not yet standardized or under procurement, the 57-mm Gun T2 was considered for the Light Tank T7 and was intended for standardization as a tank gun as soon as available. Before these guns became available, however, greater firepower, with a 75-mm tank gun, had been decided upon.

In March 1942 after observation and test of the gas deflector developed for 37-mm materiel, it was proposed that a similar gas deflector be developed for 57-mm Gun T2. As the gun has a camp operated mechanism which opens the breech automatically during recoil, any gas deflector design which changes the length of recoil must take into consideration the effect on operation of the breech mechanism. Proof of the gun, tube and recoil mechanism of the T1 and T2 carriages was completed satisfactorily by the middle of March, and road tests were then undertaken.

During the road test of the T1 carriage, a total of 380 miles, the bearing which received the drawbar broke at the trail, indicating a need for stronger design in both the drawbar and the bearing. Water and dirt were found on the traversing mechanism, indicating the need for better dust sealing or more adequate protective covers for the carriage. The elevating mechanism bushing was found to be cracked and worn. With these exceptions the carriage satisfactorily performed on the road.

Other preliminary testing difficulties occurred during a powder test of 57-mm Gun T2 on Carriage T1. The breechblock failed to close either automatically or by hand operation. It was disassembled and found warped. The block was ground off to a depth of .002 in. from the highest point,

and a portion of the rear sliding surfaces were removed. Reinstalled, operation in future firings was satisfactory up to a chamber pressure of 56,000 pounds per square inch.

Aberdeen Proving Ground reported the following flaws found during tests of the 57-mm Gun Carriage T2: The drawbar was bent, the screw on the elevating bevel gear was off 1 turn, the sides of the sleigh were devoid of lubrication, water collected in the sight bracket, the firing lever was broken, the shoulder guard bracket arm failed, and the block closed hanging the gun 22½ inches out of battery. (Recommendations for minor improvements are found in the report of 20-30 March 1942 on O.P. No. 5710.)

In April of 1942 proof firings of the pilot Guns T2, on carriages T1 and T2, were completed and only the road tests remained. A progress report of May 4 noted the fact that the drawbar had broken on both carriages.

In May the Automotive conference at Aberdeen heard the report on road tests of the experimental 57-mm gun carriage. Two hundred miles each of paved and secondary road operation were completed successfully, but after eight miles of cross country travel, the carriage lunette broke. Repairs were made and the remaining 92 miles of cross country operation run. Both units thereafter were considered satisfactory with modifications to trigger, segments, elevating mechanism, brake housing and drawbar. Tests were completed by the end of May.

Successful road tests marked the original termination point of the project as there was still no active requirement for 57-mm antitank weapons in the U.S. Army. It was decided to keep the project open however, and continue experimentation and improvement of the models on low priorities until the weapon had reached a state of greater efficiency, or until it became apparent that the U.S. would have no need for it.

Firing at a range of about 300 yards on a moving target which followed a zig-zag course at speeds varying from 10 to 20 miles an hour, 23 hits were scored out of 33 rounds. Muzzle blast effect was excessive; dust and flash shut off the view of the target from the gunner for periods as long as six to eight seconds. A muzzle brake was felt to be essential for efficient operation.

To decrease the need for new production facilities, should the experimental 57-mm antitank guns be made standard equipment, studies were made by the Ordnance Department early in 1942 to determine whether a M3A1 Field Howitzer Carriage could be so modified that it could be assembled to the 57-mm T2 gun and recoil mechanism T14 (modified 75-mm pack howitzer recoil mechanism, M3A2). It appeared that 75-mm Field Howitzer Carriage M3A1, modified with a cradle like that on the 57-mm T2 Carriage, the 57-mm recoil mechanism T14, and the T2 gun could be combined to meet all the stipulated military characteristics except that the total traverse would be 45° instead of 60°, and the gun would have to be aimed by two men instead of one. The designation assigned to this proposed carriage was T4.

A preliminary inspection at Aberdeen Proving Ground of pilot T1 and T2 carriages showed that the hydropneumatic (T2) mechanism was smoother in action. Both mechanisms operated adequately however. ~~Eventually the T1 carriage was found superior to the M1 in tests, but was superseded by the M1 because there was still no immediate requirement for U.S. Army use. (Jan. 43)~~

By July 1942 the comparative test of the 57-mm M1, T1 and T2 materiel had been completed. A general comparison table made up by APG after tests is included at the end of this section. All three carriages ~~are~~ were of the split trail type. On the M1 carriage the trails

and axles hinge about the top carriage pintle and ~~are~~ were very difficult to assemble and disassemble. The T1 and T2 carriages ~~are~~ were similar in design to the 37-mm Gun Carriage M4 and ~~are~~ were much more stable than the 57-mm M1 Carriage. The axle of the T1 and T2 carriages ~~may~~ could cant with no movement of the top carriage or the trails, which ~~may~~ could be disassembled independently. The trails on the M1 ~~are~~ were shorter and spread at a wider angle, which caused an appreciable hop when the gun ~~is~~ was fired. The segments of the M1 offered more flotation than those on the T1 and T2 types, but the proposed modifications of the segments on the experimental carriages remedied this deficiency. The M1 carriage was designed to use bronze sleeve bearings, while the T1 and T2 carriages used roller bearings to support all rotating parts.

Both the M1 and T1 recoil mechanisms ~~are~~ were of the hydrospring (Bofors) type like that on the 40-mm antiaircraft gun, while the T2 carriage had a hydropneumatic recoil mechanism like that on the 75-mm Pack Howitzer. No malfunctioning was observed in the operation of any of the three mechanisms under test conditions. The T14 ~~is~~ was more desirable than the T1 type mechanism, and facilities for its manufacture had been acquired, adequate for production of 57-mm materiel if needed for the U.S. Army.

The shield on the T1 and T2 carriages was for frontal protection only; that on the M1 Carriage offered some protection from flanking fire. Aberdeen Proving Ground recommended that the experimental shield be redesigned to include more protection area. The new shields were not very rugged and offered some difficulty during road tests because they were not bolted securely to the carriage and bent.

M1 sighting equipment had an open type sight for use if the telescope became inoperable and was generally much more elaborate than for the T1 and T2. For long range firings the M24 sighting system in the M1 Carriage

had compensation for range and azimuth, allowing a much more rapid rate of fire. The facilities for sighting and laying on all three carriages were approximately the same for short ranges.

The T2 and M1 guns have the same interior ballistics, fired the same complete rounds, and showed the same results. In the complete assembly of the M1 breech mechanism there are a total of 66 parts weighing 238 pounds, and only 46 parts weighing 102 pounds in the T2 breech mechanism.

Rock Island Arsenal was instructed to change the drawings of the T2 carriage (hydropneumatic recoil) and to modify one pilot to meet Aberdeen Proving Ground criticism on engineering detail. ~~The work progressed slowly with low priority.~~ A gun, recoil mechanism and top carriage of 57-mm T1 were shipped to the USMC in October 1942 for mounting on a fixed stand and tests necessary to the development of a new gun. Modifications for Army approval continued into the fall of 1942 and the completion date appeared to be indefinite.

In November, Aberdeen Proving Ground reported on a total of 903 rounds fired in an endurance test of 57-mm T2 materiel. The breech operating crank broke because the extractors failed to hold the breech-block open in counter-recoil, the cam follower caught on the edge of the follower arm on the crank, striking and struck the breech operating cam bracket, which cracked under the impact. As replacement parts were not available, ~~no~~ further testing was postponed. An Ordnance Committee item prepared 20 January 1943 closed out this project.

Muzzle Brakes and Gas Deflectors

Late in 1941 a muzzle brake for a captured 50-mm German antitank gun, and reputed to reduce recoil 40%, was turned over to the Ordnance Department for study. Sketches were made and Watertown Arsenal was asked to make two brakes for test with the pilot 57-mm American type antitank gun. Two other

types of muzzle brakes, one Solothurn and another German type blast deflector, were being made at the same time at Watervliet Arsenal and were to be completed by the first of May 1942. Both of these brakes were shipped to Aberdeen Proving Ground 15 May and a test program was set up for June. A report on the experimental deflectors described difficulties encountered after ten rounds of fire. The gas deflectors were assembled to the modified tubes of 57-mm M1 guns screwed on by hand and tightened by an ordinary screw driver. To see if there was any damage, an attempt was made to dissassemble one after ten rounds. It was impossible to remove the deflector because the stress caused by the muzzle blast forced the threads beyond their elastic limit. Work was suspended until a different type set screw for securing the deflector to the tube was substituted for the existing one. The disk in the gas deflector (AD-C 537) was bent outward by the muzzle blast on the first round fired. Three excess pressure rounds and subsequent firings had no further effect on it. The other deflector (AD-C 538) was not distorted in any way by firing.

Aberdeen also reported that the gas deflectors did not reduce the amount of dust raised when the gun was fired. Type AD-C537 had no noticeable effect on the reduction of the dust cloud, and type AD-C538 caused dust to be raised three to four feet on either side of the muzzle of the gun, giving the gunner fairly clear vision for about a second. Then the dust would drift into the line of sight, obscuring the target. A reduction in the size of the port holes of the later model was believed to be a solution for this problem. The gas would then be forced farther to either side of the gun, reducing the amount of dust.

Inspection of motion pictures of test firings led to the recommendation ~~in the following Aberdeen Proving Ground report~~ that a modified deflector be designed with smaller port holes at an angle of approximately 25° with

the horizontal which would force the blast upward as well as to the sides of the muzzle. By 15 July a partial test report added that the experimental deflectors did not materially affect the length of recoil or time of cycle of recoil. The following month Aberdeen manufactured a new muzzle brake with holes drilled at 30° from the perpendicular. The results of tests were not very satisfactory, but proved better than those when firing with no attachment at all.

A new type gas deflector, having dispersion holes drilled at an angle 20° from normal, was also manufactured and tested at the Proving Center. Again the results were not especially satisfactory. In October a series of tests was run firing the 57-mm gun with each of the experimental gas deflectors to see if the inside diameter had any effect on the amount of dispersion. From the dispersion table it appeared that there was none.

In November 1942 an effort was made to keep down dust by welding deflector shields to the gas deflector. The results of this attempt were not promising.

A British Mk. V muzzle brake was subsequently tested along with brakes of double baffle and horizontal hole types, and then was sent to the Infantry Board for a study of stability.

The attempt to reduce recoil and muzzle blast with a single attachment (combining the function of both muzzle brakes and gas deflectors) was not abandoned. But a satisfactory solution had not been found by September of 1944, when a new project to develop and standardize a muzzle brake was initiated by the Infantry Board after service tests had shown the inadequacy of the experimental models already submitted. (The development of this new series is traced in the chapter on muzzle brakes appearing separately in this record.)

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57-MM GUN M1 and CARRIAGES M1A3 and M2

Gun

Weight of gun	755 lb.
Weight of tube and breech ring	505 lb.
Weight of tipping parts	1,142 lb.
Length of gun (muzzle to rear face of breech ring)	116.95 in.
Length of tube	112.20 in.
Length of bore (muzzle to front of breech)	108.20 in.
Length of rifling	94.18 in.
Muzzle velocity (average, with new gun)	
Cartridge, APC-T, M86	2,700 ft./sec.
Cartridge, APCT, M70	2,950 ft./sec.
Rate of fire, normal	15 rounds/min.
Maximum (approx)	30 rounds/min.
Type of breechblock	Vertical sliding wedge
Type of firing mechanism	Inertia

Carriage

Total weight without gun	1,945 lb.
Length, overall, traveling position	16 2/3 ft.
Width, overall, traveling position	75 in.
Height, overall, traveling position	50 in.
Road clearance	10 in.
Turning radius (approx)	9 ft.
Maximum elevation	15°_{0} or 266.7 mils
Maximum depression	-5° or -88.9 mils
Elevation per turn of handwheel	10.7 mils
Limits of traverse (right or left)	45°

Recoil mechanism M12

Maximum allowable recoil	31½ in.
Elevation at which max. recoil occurs	15° or 266.7 mils
Type of recoil mechanism	Hydrospring
Weight	99 lb.
Slipper (sleigh)	95 lb.

Tires, combat	8.00 x 16
Pressure	30 lb./sq. in.
Brakes, type	Hand parking

Sighting Equipment: *

Telescope Mount M24 or M24A1 with Telescope M18
Telescope Mount M63, Telescope M69C and Instrument Light M33

*Latter is sighting equipment for Carriage M2 and replacement on older Carriages M1A3, former standard issue, 1944.

COMPARISON OF CONVENTIONAL RECOIL MECHANISMS

HYDROSPRING SYSTEM

Advantages

Simplicity of design
Ease of manufacture of system
Low initial cost
Rapidity of repair in field

Disadvantages

Wide variations in serviceability of springs (3,000 to 10,000 rounds)
High replacement rate
Bulkiness
Difficulty in securing required physical characteristics for springs

Weight prohibitive for large-caliber mobile materiel
(Disadvantages increase with increase in caliber)

HYDROPNEUMATIC SYSTEM

Advantages

Reliability of performance
Durability (~~20,000 to 40,000 rounds~~)
Smooth action
Standardization for mass production
Compactness
Adjustable to slight variations

Disadvantages

High initial cost
Specialization required in manufacture
Repairs require facilities and expert mechanics
Maintenance in storage

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CHARACTERISTICS FOR 57-mm ANTITANK MATERIAL

	BRITISH	U. S.
Caliber	2.244 in.	2.244 in.
Length	50 calibers	50 calibers
Muzzle velocity	2700 ft./sec.	2700 ft./sec.
Pressure, maximum	46000 lb. p.s.i.	46000 lb. p.s.i.
Recoil	30 in.	30 in.
Length of gun	116.95 in.	116.95 in.
Type of breech mechanism	Semi-automatic	Semi-automatic
Weight of gun and mechanism	743 lb.	650 lb.
Weight of gun and carriage	2,352 lb.	2,000 lb.
Elevation, maximum	15°	15°
Elevation, minimum	-5°	-10°
Traverse	90°	60° or more

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57-mm ANTITANK MATERIEL

GENERAL COMPARISON	M1	T1	T2
Total weight (lbs.)	2700	2,400	2,425
Weight gun and tube (lbs.)	749	628	624
Trail spread	90^0	60^0	60^0
Traverse	90^0	60^0	60^0
Elevation	15^0	15^0	15^0
Depression	-5	-10^0	-10^0
Overall length (traveling) (in.)	200½	220¼	222¼
Overall length (firing) (in.)	167¼	200	202
Overall width (traveling) (in.)	75	76 3/4	76 3/4
Overall width (firing) (in.)	160½	168	168

COMPLETE ROUND TABLE FOR SERVICE AMMUNITION FOR 57-MM GUNS

Note References	Designation of Cannon	PROJECTILE Kind	TYPE	Model	Filler Kind	Filler Weight (lb.)	Weight as Fired (lb.)	FUZE Type and Model	Action	Cartridge Case	PROPELLING CHARGE Kind	Weight (lb.)	PRIMER Model	Type
3	M1,6Pr.7 Cwt.	CARTRIDGE	APC-T	M86	Exp.D	0.094	7.27	B.D.,M72	Delay	M23A2	NH,M1	2.43	M1B1A2	100-gr. perc.
4	M1,6Pr.7 Cwt.	CARTRIDGE	APC-T	M86	None	-	6.71	None	-	M23A2	NH,M1	2.25	M1B1A2	100-gr. perc.
4	M1,6Pr.7 Cwt.	CARTRIDGE	AP-T	M70	None	-	6.28	None	-	M23A2	NH,M1	2.62*	M1B1A2	100-gr. perc.

AP-T-armor-piercing tracer
APC-T-armor-piercing-capped tracer
Exp. D-explosive D
B.D.-base detonating
NH-nonhygroscopic
gr.-grain
per.-percussion

1- M23A2 is standard. Substitute standard is CASE, cartridge, 57-mm, M23A2B1, a steel case.
2- M1B1A2 is standard primer. Alternative is: PRIMER, percussion, 100-grain, M1A2.
3- Fuze, B. D., M72, contains a tracer, burning time approximately 4.5 seconds in flight.
4- Projectile contains a tracer, burning time approximately 4.5 seconds in flight.
*- Weight of charge for production of muzzle velocity of 2,950 f/s. Weight of charge for round with muzzle velocity of 2,800 f/s is 2.25 lbs.

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REFERENCES

TM 9-303, "57-MM Guns M1 and Mk. III (British) and Carriages M1, M1A1, M1A2, M1A3, and M2," 25 April 1944.

TM 9-1303, "57-mm Gun M1 and Carriages M1A3 and M2," 2 December 1944.

OCM 16489, 18 February 1941, orders preparation of Ordnance drawings of British 2.244 inch antitank gun and carriage.

OCM 16674, 1 May 1941, initiates project to design and manufacture pilots, 57-mm Gun T2 and Gun Carriage T1 for test. Approved by OCM 16966, 2 July 1941.

OCM 16722, 15 May 1941, establishes model designations on British type 6-pounder gun as 57-mm instead of 2.244 inch.

OCM 16831, 9 June 1941, disapproves development of a 57-mm antitank gun and carriage. (This decision reversed by OCM 16966, 2 July 1941, approving the development of experimental 57-mm materiel.)

OCM 16940, 3 July 1941, recommends rated maximum pressure and muzzle velocity for 57-mm Gun M1.

OCM 17944, 19 March 1942, initiates project to develop experimental gas deflectors or muzzle brakes for 57-mm Guns.

OCM 18459, 9 July 1942, establishes velocity levels and pressure limit for 57-mm Gun M1.

OCM 18485, 16 July 1942, recommends 57-mm APG projectile M86 for adoption as Standard, and 57-mm AP Shot M70 Substitute Standard.

OCM 18615, 13 August 1942, rejects experimental counterweight for recoiling parts on 57-mm Gun Carriage.

OCM 18921, 24 September 1942, recommends modification of 57-mm Gun Carriage M1 to Carriage M1 to provide free traverse instead of gear traverse.

OCM 18994, 8 October 1942, approves modification of 57-mm Gun Carriages M1, M1A1 for free traverse with designation M1A2.

OCM 20125, 8 April 1943, recommends modification of 57-mm Carriage with new lunette and drawbar assembly when issued to American Infantry, with designation M1A3. Approved by OCM 20694, 10 June 1943.

OCM 20700, 10 June 1943, directs service tests of 57-mm equipment by Airborne Command.

OCM 20961, 8 July 1943, fixes rated maximum pressure and velocity levels for 57-mm Gun M1.

OCM 21045, 15 July 1943, directs test of M1 Gun, M1A2 Carriage by Armored Force and Cavalry Boards.

OCM 21352, 19 August 1943, directs test of 57-mm Carriage M1A1 against the 57-mm Carriage with free traversing mechanism to determine which mechanism is preferable.

OCM 21409, 26 August 1943, directs test of 57-mm Gun M1 by Tank Destroyer Board at Camp Hood, Texas, and comparison with 75-mm Gun T16.

OCM 21738, 7 October 1943, cancels restricter rings for 7.50 x 16 tires for divided wheel on 57-mm Carriage M1A3. Approved by OCM 22009, 4 November 1943.

OCM 21966, 28 October 1943, records decision of Airborne Command that M1A3 Carriage and 57-mm Gun M1 are unsatisfactory for Airborne operations.

OCM 22653, 20 January 1944, standardizes the modified M1A3 carriage with designation M2; M1A2 carriage to be substitute standard, and M1A3 carriage, limited standard. Approved by OCM 22855, 10 February 1944.

OCM 22878, 10 February 1944, records results of test of M1A2 carriage by Armored Board.

OCM 23060, 2 March 1944, directs that British Muzzle Brake Mk. V be sent to Infantry Board for study of stability.

OCM 23510, 13 April 1944, approves test of M2 Carriage with screw elevating mechanism by Aberdeen Proving Ground and Infantry Board.

OCM 25428, 12 October 1944, modifies Standard Nomenclature Lists for 57-mm Gun Materiel.

OCM 25795, 16 November 1944, records that side shield assembly will be retained on M1A3 and M2 carriages.

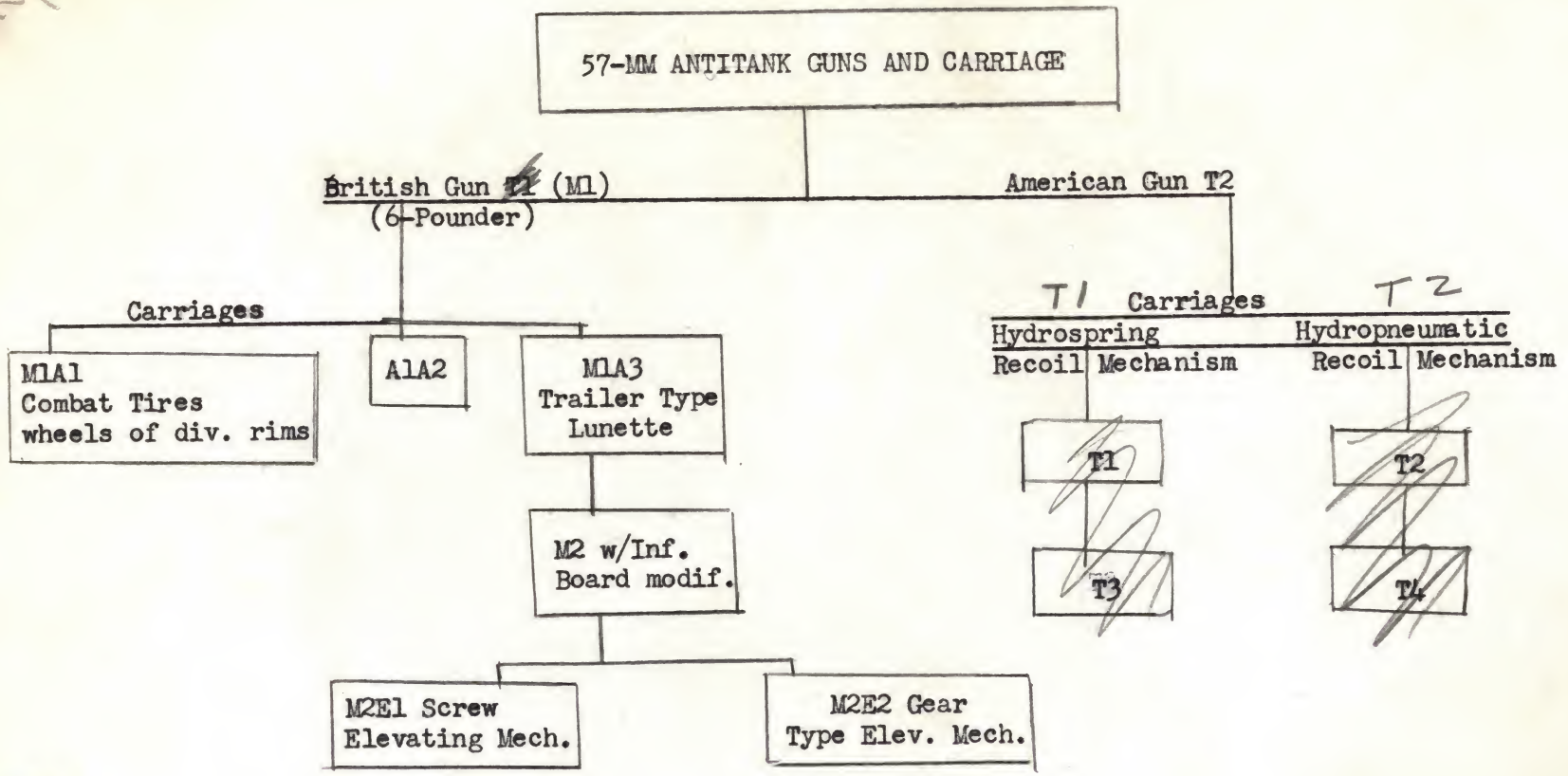
Airborne Command test report, Project #118, Camp Mackall, North Carolina "Test of 57-mm AT Gun M1," 16 August 1943.

Armored Board Report, Project No. 461, Fort Knox, Kentucky, "Final Report on Test of 57-mm M1 Gun on Carriage M1 and M1A2," 25 October 1943.

Aberdeen Proving Ground Report, 1st Report on O.P. No. 5810, "57-mm experimental Gun Carriages T1 and T2 Testing hydrospring vs. hydropneumatic (Pack Howitzer) type," 11 June 1942.

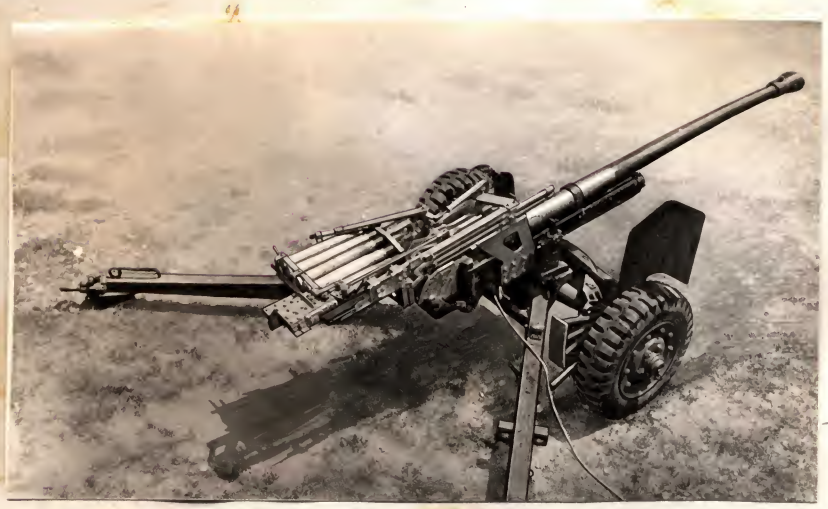
Cavalry Board Report, File No. 472.1,"Service Test of 57-mm Antitank Gun M1 (Mounted on Gun Carriage M1A2), 8 February 1944.

Infantry Board Report No. 1702, "57-mm Gun Carriages M2E1 and M2E2", Fort Benning, Georgia, 31 October 1944.



BRITISH 6-POUNDER

TD 5177



6-Pounder Mk VI, equipped with Molins Automatic Loader Mk. I, and assembled to 57-mm Gun Carriage M1A2.

TD 5179

Close-up showing automatic loader

TD 5208

3/4 left rear view of British 6-pounder with automatic loader on 57-mm Gun Carriage (American) M1A2.

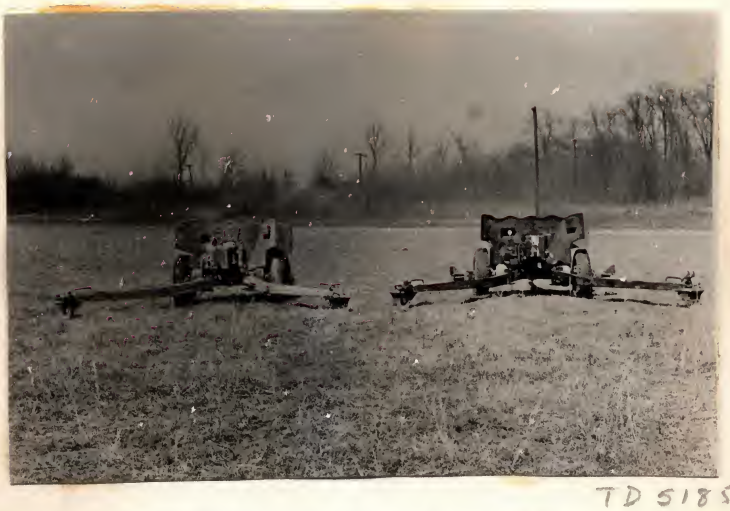
TD 5178

TD 5187

57-mm Gun Carriage M1, after 300 mile road test

57-mm Gun Carriage M1, side view, maximum depression

TD 5191



TD 5185

57-mm Gun Carriage M1 after 300 mile road test. 57-mm by International shown for comparison.

57-mm Gun Carriage M1, general close-up showing condition after 300 mile road test.

TD 5184

57-mm Gun Carriage M1, front view

TD 5188

TD 5186

TD 5202

57-mm Gun Carriages M1 and T2, at maximum depression before firing

57-mm Gun Carriage M1 traveling position

TD 5190

57-mm Gun Carriage T2 in traveling position

TD 5201

TD 5209

TD 5203

57-mm Gun Carriage M2 in firing position

3/4 front and rear views, maximum elevation

(to come)

TD 3908

57-mm Gun Carriage M2 in firing position

(to come)

TD 3907

57-mm Gun Carriage M2, trails supported by caster

TD 1231

57-mm Gun Carriage M1, side view (right)
maximum elevation

TD 252

57-mm Gun Carriage T2, side view (right)
maximum elevation

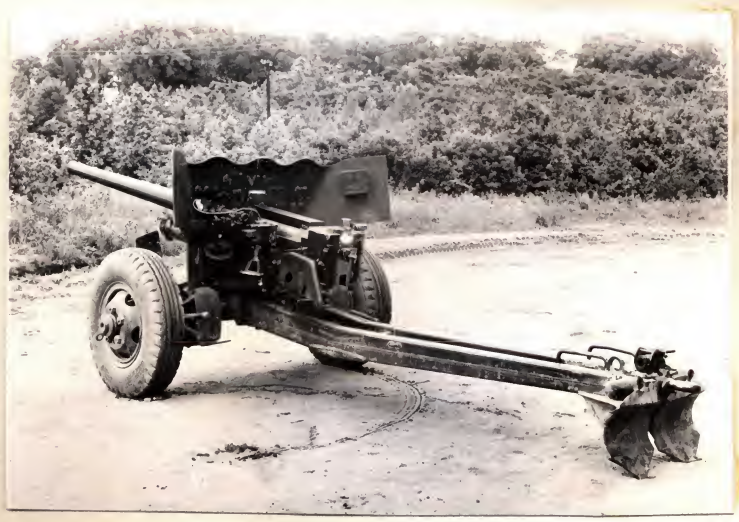
57-mm Gun Carriages T1, T2, and M1; front and rear views

TD 5192

TD 5194

TD 5195

57-mm Gun Carriages T1, T2, and M1 (side view)



TD 5189

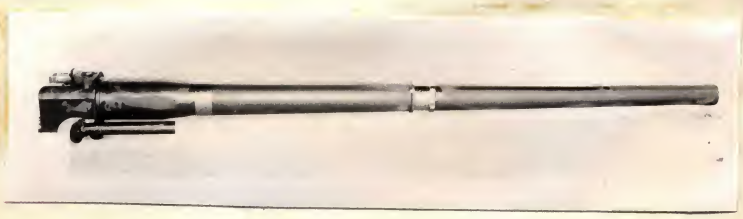
57-mm Gun M1, Carriage M1, traveling position

57-mm Gun Carriage T1
front view, maximum
left traverse, and
maximum elevation
TD 5198

right side view
maximum elevation
TD 5197

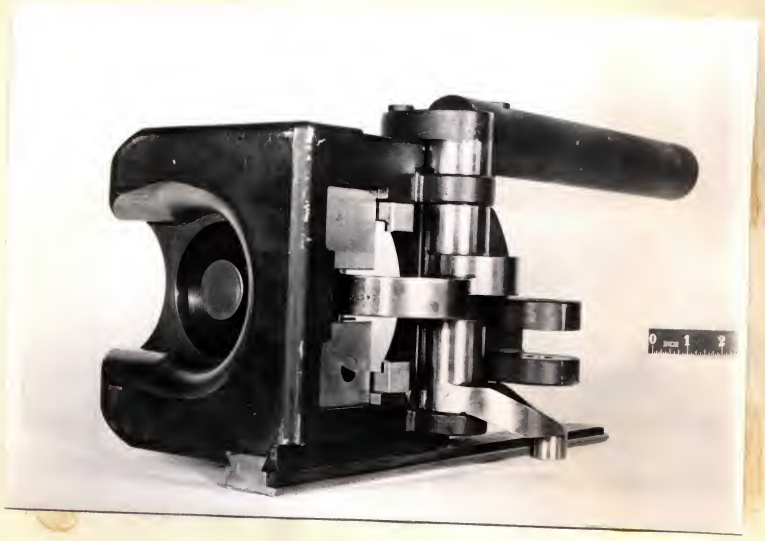
TD 5193

3/4 SIDE VIEW OF 57-MM GUN CARRIAGES
T1, T2, and M1



TD 5199

57-mm Gun Tube T2

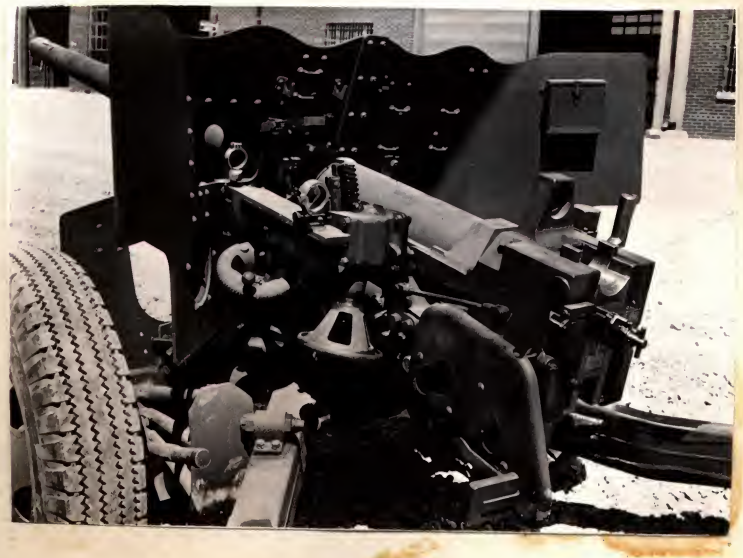


TD 5200

57-mm Breech Mechanism for T2 Gun, closed position

TD 5180

57-mm Gun M1 on Carriage M1A2, note shoulder traverse.



TD 5181

57-mm Gun M1 on Carriage M1, with geared traverse.

TD 5204

General view, 57-mm Gun Carriage M2E1.

TD 5210

57-mm Gun Carriage M2E1, close-up showing experimental elevating mechanism.

TD 5206

TD 5211

57-mm Gun Carriage M2E2 (with standard traversing mechanism)

TD 5205

57-mm Gun Carriage M2E2, in firing position

Elevating mechanism for

57-mm Gun Carriage M2E2

(disassembled)

TD 5183

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TAPERED BORE DEVELOPMENT

Light highly maneuverable antitank guns such as the 37-mm Gun M3 became less destructive as the fire power and armor thickness of tanks increased. The effective range at which these guns could be employed was reduced by the use of heavier armor. It soon became apparent that, if the smaller weapons were to be successful against modern tanks, it would be necessary to give them considerably higher muzzle velocities and greater penetration. Unfortunately, an increase in muzzle velocity in straight bore guns entails a consequent rise in powder pressure which, in turn, makes additional gun weight inevitable and causes erosion of the bore to occur more rapidly.

There are definite limitations to conventional design of projectiles for the purpose of obtaining higher velocity. For instance, an attempt to attain a low sectional density (or small ratio of mass to area) in a projectile would result in augmenting air resistance to the point where such a rapid loss of velocity during flight would occur that the initial high muzzle velocity would be without practical value. It is therefore desirable to achieve super velocities by other means than excessive powder loads or reduction of sectional density of projectiles.

A method used to secure high velocities while keeping pressures within reasonable limits, and without adversely affecting the ballistic properties of projectiles, is to employ a gun tube with a tapered bore. The tapered bore has the same effect in increasing gas pressure that a constantly narrowing nozzle has on the pressure of water being forced through it when it is attached to a garden hose. Since a tapered bore tube will have a greater volume than a straight bore tube of the same muzzle caliber, a projectile of a given mass and emergent diameter may be fired at a higher

velocity from a tapered bore gun than from a straight bore gun without an increase in pressure or the use of a longer tube.

It is obvious that a tapered bore makes the use of some design of deformable projectile obligatory. If a projectile is fired which has a large area only at the breech end of the gun, and a constantly decreasing area as it travels through the bore until a minimum area is obtained as it leaves the muzzle, its final sectional density will be large enough for it to have good ballistic qualities. Such a projectile will form a gas seal behind which the pressure will progressively increase from the instant of firing until it reaches a maximum as the shell leaves the muzzle.

The principles of the tapered bore gun and the deformable projectile are not new. In the France-Prussian War of 1870 the Germans employed in their needle gun a subcaliber bullet which was seated in a "sabot" of larger diameter. This "sabot" fitted the bore and dropped away from the bullet upon leaving the gun. The first tapered bore gun was a 9.21/7.78-mm rifle invented by Puff in 1903. It fired a 210 grain bullet fitted with flared rotating bands that could be forced into grooves in its body. The muzzle velocity was 2,700 feet per second.

No real advance in the design of tapered bore guns or ammunition for them took place until 1930 when E. Gerlich, an American-born German engineer, completed a tapered bore rifle known as the Halger-Ultra rifle. This weapon was tested at Aberdeen Proving Ground in 1932. Its 125 grain monel metal bullet, which attained a muzzle velocity of 4,406 feet per second, perforated one-half inch armor plate at 300 yards range. The bullet was equipped with two circular "skirts" or rotating bands, the body being cut away behind the skirts. The skirts were 9.27-mm in diameter, 0.4-mm thick, and were attached at an angle of about 45° with the longitudinal axis of the bullet. The

diameter of the bullet proper was 7.02-mm. Until 1941 American experiments with tapered bore guns were confined to small arms.

Meahwhile Gerlich had designed a 28/20-mm gun which was improved, after his death, by the Ultra Company of Monaco. In 1936 tests of this gun at Otterup, Denmark, were witnessed by a representative of the United States Army and several descriptive reports were forwarded to War Department officials. With further refinements this gun was used by the Germans in their North African campaign. It was the only known combat use of ~~the~~ a tapered bore antitank gun, mounted on a light two-wheeled carriage ~~and~~ it was captured by the British near the Halfaya Pass in the spring of 1941. Known as the 28/20-mm Anti-tank Gun Model 41, it fired a 2,030 grain projectile with a muzzle velocity of 4,580 feet per second. The rifled portion of the barrel was 50 inches long, the bore tapering from 28.3-mm at the origin of the rifling to 20.9-mm at the muzzle. The 12 grooves of the rifling were of uniform width, but the lands decreased in width towards the muzzle. The pitch of the rifling was not uniform. The projectile consisted of a tungsten carbide core covered by a thin lead sleeve, a rear and a forward skirt of soft iron, and a magnesium alloy ballistic cap screwed on the nose. The skirts formed a gas seal, passing through the barrel and fell free from the projectile as it left the muzzle. A manual which accompanied the gun stated that the serviceable life of the barrel was 400 rounds. Penetration of armor plate at 30° was 69 millimeters (2.72 inches) at 100 yards and 53 millimeters (2.08 inches) at 400 yards.

American 28/20-MM Tapered Bore Gun

Reports of the German Model 41 revived American interest in the tapered bore principle, and in September 1941, the Ordnance Department began the

development of a 28/20-mm tapered bore gun to have a muzzle velocity of approximately 4,500 feet per second. The first design was to follow as closely as possible that of the German materiel. Upon recommendation of the Aberdeen Proving Ground Ballistics Laboratory, based on tests which indicated that comparable high muzzle velocities could be obtained without a tapered bore using a long cylindrical bore, a project was initiated for the construction of a high velocity cylindrical bore gun for comparison with the tapered bore tube. The tapered bore gun was designated 20-mm Gun T5, while the cylindrical bore gun, based on the multiple expansion principle, was known as 20-mm Gun T6. Each of these guns was to be mounted on a 37-mm Gun Carriage M4. Projects were also established for the manufacture of a tapered bore gun T8 with characteristics similar to those of the T5, to be used as a powder test gun for the latter weapon, and for a cylindrical bore gun T13 to serve as a powder test gun for the T6. Both the T8 and the T13 were designed with the idea of later use as subcaliber guns for the 4.7-inch howitzer.

A 37-mm tube forging or casting was to be used for the tube of the 20-mm Gun T5. The difficulty of rifling a tapered bore tube made future rapid quantity production of such guns problematical, although progress in this direction was indicated. Despite the problems which arose during manufacture, the 20-mm Gun T5 was completed and shipped to Aberdeen Proving Ground in October 1942. It has never been fired.

Delivery of the 20-mm Gun T6 was delayed because Watervliet Arsenal encountered trouble in making an acceptable tube. The extrement length of 160 calibers combined with the small bore to offer such serious impediments to manufacture that it was decided to build another cylindrical bore gun

of the same caliber with the barrel in two sections. This gun, designated 20-mm Gun T17, was to be mounted on 37-mm Gun Carriage M4.

When the two-piece tube for the T17 gun arrived at Aberdeen it was discovered that the breech section had not been machined properly. The recess was not big enough to allow the lip or extractor of the cartridge case. It was returned to Watervliet Arsenal, remachined, and shipped back to Aberdeen Proving Ground with two spares where it has awaited test firing since June 1944.

Partial powder tests were made with the 20-mm T8 and T13 guns, to develop high velocities but the low priority of this project postponed further development and also the comparative test planned for the T5 tapered bore gun with the T17 cylindrical bore gun.

It is claimed by advocates of the tapered bore gun that a larger amount of powder energy is expended on the bullet than is the case in straight bore guns, and that a reduction of erosion is obtained in the tapered bore tube because of better obturation. These questions of relative efficiency and rate of erosion are still matters for argument, and cannot be readily answered as too many factors are involved. This project had been suspended for approximately a year when formal action in June 1945 closed it with the recommendation that the four experimental guns be assigned to the Ordnance Research and Development Center as a historical proof weapon facility.

37-MM Tapered Adapter Guns

The possibility of obtaining higher velocities from standard 37-mm guns by use of special ammunition fired in conjunction with tapered adapters was not over looked. Two adapters, the T7 and T8, were designed for assembly to the 37-mm antitank gun M3. They were essentially separate gun barrels, threaded at the rear end, that could be secured to the M3 gun by a collar

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which screwed on the threaded muzzle of the M3. The overall length of the T7 was 30 inches while the T8 was 24 inches long. The bores of both adapters were 1.505 inches in diameter at the threaded end, but tapered to 1.102 inches in diameter in the first 12 inches of the tube, after which the diameter was uniform to the muzzle.

A variety of shells were designed for use with the 37-mm adapters. The first projectile tested was the special High Velocity T22 with an aluminum jacket. During firing, one adapter was forced out of line .01 inch, while a bulge occurred in a second adapter. This bulge was probably caused by an excess of metal in front of the bourrelet band. The projectile was also unstable.

The unsatisfactory T22 shell was succeeded by the T23, a projectile with a tungsten carbide core in a duralumin jacket. At the rear of the core, interlocked to the jacket, was a collapsible tail piece of SAE 1010 steel with a groove for the rotating band. The cartridge case was crimped to the tail piece. A collapsible annular bourrelet ring was positioned by the rear shoulder on the jacket. The weight of the core was approximately .78 pounds. It was found that the tungsten carbide cores broke into relatively small pieces after penetrating armor plate, a factor to be considered in performance against spaced armor.

Tests of the T23 projectile fired from the 37-mm Gun M3 with Adapter T8 resulted in complete penetration by the tungsten crbride core of 3-inch and 4-inch class B homogeneous armor plate at 20° obliquity at a range of 100 yards. The muzzle velocity developed was 4,400 feet per second. For comparison the 1.92 pound APC Shot M51, was fired from the M3 Gun without the adapter. This projectile, with a muzzle velocity of 2.886 feet per second, failed to penetrate three inch armor at 100 yards, the nose remaining

in the plate. The plate was bulged in the back, a star crack appearing on the bulge.

The various experiments conducted with tapered bore adapters and special projectiles indicated the feasibility of obtaining supervelocities by such means. They also demonstrated the ability to secure superior armor penetration by the use of tungsten carbide cores in light weight shells which could be fired at velocities of more than 4,000 feet per second. Fragmentation of these shells was found to be less lethal against crews withing the tanks than in the case of the heavier, lower velocity projectiles when they effected penetration.

The method of attaching adapters to the gun by a threaded collar frequently resulted in their getting out of alinement. It was discovered that the terrific pull caused by the forward momentum of the shell, when it was suddenly choked by the tapered portion of the adapter, subjected the threads of the gun muzzle, adapter and collar to excessive strains which tended to strip them or to throw the adapter out of line.

The British Littlejohn type adapter was tested early in the development of 37-mm antitank guns. It was found that the skirt folded with difficulty on the tapered bore projectile, and that the adapter became distorted in expansion, causing inaccuracy in firing after several rounds. This adapter was dropped in 1942 after the initiation of the high velocity needlepoint projectile development. A more exhaustive treatment of special tapered bore and super-velocity projectiles will be found in the Ammunition Volume(s). These include the T23E1 projectile with a longer ogive than the T23; the T24 and improved "T24E1" series.

57/37-MM and 57/40-MM Guns

The project for development of high velocity tapered bore guns initiated

early in 1942 included plans for a 57/37-mm gun. This was found impractical, however, from a manufacturing standpoint and the tapering effect was to be achieved with an adapter bringing the 57-mm gun down to 40 millimeters at the muzzle. The 57-mm gun with a 57/40-mm adapter (T10) underwent preliminary firing tests 27 April 1942 using projectiles T6 and T7. A velocity of about 4500 feet per second was attained. But the decrease in diameter was still too great for the ammunition at that time. Development was continued in the hope of securing a satisfactory projectile and adapter combination. Final reports on this project are not yet available but are to be completed by the end of the summer 1945.

No attempt was made by this country to build guns of a larger caliber on the tapered bore principle although Germany had some success with a 75/55-mm gun.

REFERENCES

OCM 17188, 4 September 1941, recommends the development of a 28/20-mm tapered bore gun to be designated 20-mm Gun T5, and a straight bore gun T6. Both guns to have muzzle velocities of approximately 4,500 feet per second and be mounted on 37-mm Gun Carriage M4. Recommends development of ammunition for 28/20-mm Guns T5 and T6. Approved by OCM 17292, 2 October 1941.

OCM 27960, 14 June 1945, recommends cancellation of the development project for 20-mm Guns T5, T6, T8, T13, and T17.

O.O. 472.8/900, 16 July 1941, contains comments by Watervliet Arsenal on the manufacture of gun tubes with tapered or conical bores.

O.O. 471.57/62, 9 August 1941, requests Ammunition and Artillery Divisions, Industrial Service, to start design of tapered bore gun and ammunition therefor, copying German materiel closely for first design.

Memorandum, 29 August 1944, from Cannon Branch, Artillery Development Division, Research and Development Service Branch, Artillery Development Division recommends cancellation of project for development of 20-mm T5, T6, and T17 Guns.

Aberdeen Proving Ground Ballistic Laboratory Report No. 221, asserts comparable high velocities can be obtained without tapered bore; hence a tapered bore project should include a parallel development of a cylindrical gun, 10 February 1941.

Aberdeen Proving Ground, First Partial report on German 28/20-mm antitank gun and 9th report on O.P. No. 5772, 15 December 1942

Aberdeen Proving Ground report, Second Partial report on the German 28/20-mm antitank gun and 16th report on O.P. No. 5772, 18 September 1943.

National Defense Research Committee Report No. A-43, Preliminary Report, "A brief History of Tapered Bore Guns," by John S. Burlew, 15 April 1942.

Ordnance Department Report on High Velocity Developments with British and German Supplement, Office, Chief of Ordnance, 19 October 1943.

37-mm Carriage M4 with 37/28 tube
in firing position (M3 tube T1 extension)

TD 153

TD 5176

57/40-mm Gun Adapter, 3/4 view close-up

TD 5175

57/40-mm Gun Adapter in position for firing

3-INCH ANTITANK GUN DEVELOPMENT

Following the standardization of the 105-mm Howitzer Carriage M2 early in 1940 the Office of the Chief, Technical Division, Ordnance Department requested a layout showing the 3-inch Antiaircraft Gun T9 and recoil mechanism mounted on the howitzer carriage for use as an antitank weapon of greater power than the 57-mm or British 6-pounder. It was soon seen that unless the 105-mm Howitzer breech ring was used with the howitzer breech mechanism the combination would be awkward. The semi-automatic feature of the T9 antiaircraft gun was sacrificed by this adjustment, but the characteristics of the proposed weapon were such that its desirability outweighed the disadvantage of ~~sacrificing the~~ losing semi-automatic ~~feature of the antiaircraft gun.~~ operation. And furthermore, tests showed that the gun could be manually loaded as fast as necessary. Tests on gun and carriage materiel were by-passed as both had been adequately proven prior to the suggestion of their combination for antitank use.

Therefore, by the end of December 1940, War Department approval of military characteristics was given and designations assigned to the components of the 3-inch antitank weapon. The gun, T10, Recoil Mechanism T5, and Carriage T1 had a muzzle velocity ranging from 2600 to 2800 feet per second, and a range of about 14,200 yards. The weight of the carriage was 4,800 pounds. Provision was made for 45° elevation and 60° total traverse. Armor penetration of the 15 pound projectile in Class B armor plate was 4 inches at 500 yards and 3.7 inches at 1,000 yards. The only drawback to the new antitank combination was pointed out by the infantry in a statement that the need for antitank materiel of such great weight did not seem great enough to counteract its poor mobility.

More about development of the Gun, its features, etc.

Rock Island Arsenal was asked to develop a pilot 3-inch gun or a towed carriage after drawings were submitted by the Technical Service and the Artillery Division, Industrial Service.

The use of the 3-inch Antiaircraft Gun T9 and its breech mechanism on the 105-mm Howitzer Carriage M2 would have involved a redesign of the cradle to clear the breechblock and appeared to be an impractical arrangement. Using the 3-inch antiaircraft Recoil Mechanism T4 and the T9 gun was also studied, but this plan was rejected as it meant the complete redesign of the top carriage. A satisfactory solution was reached when it was found that by using the breech ring and breech mechanism of the 105-mm Howitzer M2A1, the 3-inch tube (T9), the howitzer recoil mechanism and carriage, a practical combination was accomplished. A collar was added to the howitzer breech ring to compensate for the recoil thrust, and The fire control equipment of the 105-mm Howitzer Carriage M2 was modified for antitank use.

Meanwhile plans were made to mount available 75-mm guns of the M1897 type on new split trail carriages M2A3 and equip them with antitank sights ~~for antitank use~~. This adaptation of the "French 75" was carried out during 1941, and all remaining 75-mm guns were to be mounted in this way rather than on the carriage of French design with firing platforms similar to those used by the British for their 25-pounder.

Another 75-mm antitank gun was devised by combining the newly developed 75-mm tank gun, standardized in June of 1941, with a modified field howitzer carriage. Two pilots consisting of the 75-mm tank gun M3 and the 75-mm field howitzer carriage ~~M3A3~~ M3A1 modified to take the tank gun and redesignated T16, were to be combined with the ~~pack~~ 105mm howitzer recoil mechanism M1A4 T13 and assembled for test. (This project was canceled before completion and tests were never made.) — THESE CARRIAGES WERE TESTED AT ABERDEEN PROVING GROUND AND THE RESULTS INDICATED THAT THIS WEAPON HAD MERIT.

WHAT WAS FINAL DISPOSITION & WHY?

further combination were assembled from the data obtained from the previous project, a pilot carriage was designed and manufactured using the modified components, which were combined in the first pilots. The components of this weapon were 75m/m Gun Carriage T16, 75m/m Gun T14 and Recoil Mechanism T31. Proposed sighting equipment consisted of Telescope T52E1 and Telescopic Mount T78. After a preliminary test at Aberdeen Proving Ground this carriage was sent to the Service Board for service tests; the project was cancelled due to lack of requirement for 75m/m materiel by the using arms.

Replacement of unserviceable 75m/m M1897A4 Gn M3 and M5 Mounts on the 75m/m Gun Motor Carriages M3 and M3A1, a project was initiated to modify the 75m/m tank gun M3 by providing a sleigh to fit into the cradle and by redesigning the breech operating handle and firing mechanism. This gun was designated T15. After tests were completed at Aberdeen Proving Ground, the project was cancelled due to the lack of requirement for 75m/m anti-tank guns. The anti-tank requirements were being more satisfactorily met by the new development program for 76m/m Gun T3 on experimental carriages T4 and T5. It was obvious that the 75m/m gunwould never have the punch of the new " 76 " and all further development effort was directed toward rapid completion of the latter weapon. The manufacture and improvement of the original 3-Inch Gun continued, however, under the direction of the Industrial Service, Ordnance Department.

3-Inch Gun M5 and Gun CarriageM1

In February 1941 when the project to mount a 3-Inch gun on a 105m/m Howitzer carriage was approved none of the new howitzer carriages had been manufactured, but preliminary tests were conducted with a modified pilot howitzer carriage (T5). Watervliet was assigned the job of manufacturing the 3-Inch Gun T10 from existing forgings and tools. The pilot was delivered to Aberdeen Proving Center 25 September 1941 where it was to be tested before officials from interested services. The 3-Inch Navy projectile, then standard

for 3-inch guns, was used in the test. Firings were witnessed in October, and proved satisfactory, whereupon the War Department authorized the immediate procurement of 100 3-inch antitank guns to be mounted on 105m/m Howitzer Carriage M2. Meanwhile, the completed unit was to be shipped to Fort Bragg

for service tests by the Field Artillery Board. The proposed nomenclature, adopted in November 1941, relating to the new antitank gun and associated equipment was as follows: 3-inch Gun M5, 3-inch Recoil Mechanism M9, Gun Carriage M1, Range Quadrant M6, Elbow Telescope M29, Telescope Mount M21, Telescope Mount M23, Panoramic Telescope M12. In the case of the Panoramic Telescope, the M5 was to be substitute standard equipment if the M12 was not available.

Tests at Aberdeen late in 1941, ~~and~~ reported upon early in January 1942, indicated a successful performance of the 3-inch Gun T10 on 3-inch Gun Carriage T1, ~~with~~ (was used in these tests) Mk.IAI ammunition. A cross-country road test of 243 miles showed no ill effects from bouncing of the tires or shaking of the lunette in the pintle. The length of the gun did not present any difficulty, but the turning radius for the towing vehicle was affected by the spades of the carriage hitting the back of the towing body when too sharp a turn was made. The test covered difficult terrains, as the carriage was towed through trees, across ditches, and through mud and water holes. Then it was placed in an unheated building overnight where the temperature went as low as 10° F. (plus or —?) In the morning the brake bands were frozen to the drums and it was necessary to tap the brake drums loose before the wheels would turn.

Adapter parts and the equilibrator for the T1 (M1) carriage were made by Rock Island Arsenal and shipped to Aberdeen Proving Ground 1 September 1941. The spring type equilibrator was needed on this weapon to assist the manual effort required for elevating the gun. It connected the rear end of the cradle to the top carriage, as the preponderance of weight supported by the cradle ~~is to the~~ was in front of the trunnion bearings when the recoiling parts ~~are~~ were in battery. In recoil the sleigh, gun tube, and two recoil cylinders moved to the rear as a unit. It was not until 23 September when the gun tube arrived at A.P.G. that the materiel could be assembled

for test. An interference on the cradle adapter was found during preliminary assembly of the weapon, and the piston rod was found to be too short. As soon as an extension could be sent from Rock Island Arsenal and the cradle corrected, proofing was to start. Another delay occurred because no outrigging weights had been provided. However, these difficulties were rapidly attended to, and firing

was found to be satisfactory. After firing 242 rounds, which included cold room tests at temperatures of 0 and -10° F, A.P.G. recommended that the trail weights (31-pounds each) be moved and nitrogen pressure reduced to 1,000 pounds. Experimental respirators were installed in the recoil mechanism and further firing tests run. A respirator with a nitrogen pressure of 800 pounds was required because of the seven second cycle on recoil and counterrecoil of the gun. With the normal pressure of 1200 pounds the gun slammed into battery.

By the end of November 347 miles of road testing had been satisfactorily completed. The gun was fired at a moving target to investigate the stability of the carriage. Seven rounds were fired in 45 seconds at a target, 4 x 10 feet, which was being towed at a range of 1600 feet at 10 m.p.h. Direction was changed three times in crossing the field of fire. Four definite hits were made, the remaining three rounds appeared to be hits, but the first two rounds had damaged the target and reduced its visible area. Using the same target, another run of seven rounds was fired in 45 seconds, three hits being scored. The trail weights were not used and sand bags were not needed, as the carriage was very stable during rapid fire. It took 18½ seconds to move the carriage about and aim the gun at another target which was 90° from the previous target. The experimental respirators reported upon after tests in November were accepted as standard.

After the 500 miles of road tests were completed, and full reports made upon performance, the pilot was shipped to Fort Bragg for service tests. An experimental manganese aluminum bronze elevating worm wheel was included in the shipment. This part (C68917) was found to be satisfactory after 2,010 rounds were fired and the carriage was subjected to 500 miles of road test. Combat tires were mounted on the carriage.

By March of 1942, recommendations had come from Fort Bragg as a result of the FAB tests held there. There was difficulty in traversing unless the wheels of the carriage were level: traversing "uphill" was extremely hard and traversing "downhill" was jerky. Also, the traversing and elevating handwheels were positioned in such a way that it was almost impossible for one man to perform both operations and keep his eye to the sight. A muzzle brake was recommended so that the gunner's vision would not be ~~obliterated~~ obscured between rounds. Adequate shields designed to protect the gun crew as fully as possible within reasonable weight limits were also recommended by the Field Artillery Board.

Using Services asked for cancellation of 3-inch M5 on 105-mm Howitzer Carriage in a letter 13 May 1942 from Headquarters, AGF. Army Ground Forces. The Chief of Ordnance felt the decision to be a "deplorable and definite mistake in view of recent executions of 88-mm in Libya." However, the Tank Destroyer Command, sole users of the 3-inch antitank gun, considered it essential that this gun be self-propelled. The Infantry Board felt that the mobility of the towed carriage was poor, and the weapon too heavy for infantry use.

A month later, after reconsidering the project, an agreement was reached to reopen it, and to develop a self-propelled antitank gun motor carriage as well. By 21 August 1942 using arms required 1,000 3-inch Guns on 105-mm Carriages.

Results of tests at Fort Bragg were reported in July 1942, and ~~essentially~~ the reports consisted of ~~the following~~ contained various criticisms. In general, the carriage was not properly designed to accommodate the gun, ~~which~~ This was felt to be mainly responsible for many small difficulties. ~~Other troubles included~~ It was the difficulty ~~in~~ to traverse ~~ing~~ the mount, particularly on side slopes, as previously mentioned. Gun blast obscured vision for several seconds following each round, ~~making~~ interfering with observation

of ~~results of firing very difficult,~~ fire, particularly ~~observation of~~ in the case of a moving targets, ~~for which the weapon was designed.~~ The elevating handwheel was inconveniently placed, ~~and the carriage~~ was ~~too heavy for manhandling by a full gun squad even for short distances.~~ Direct laying by the two-man system ~~required~~ (was required to stand in an exposed position) the No. 1 cannoneer ~~to stand~~ outside the wheel ~~in order to use~~ to operate the handwheel while using the elbow telescope, ~~and operate the handwheel. This is a very exposed position.~~ In direct laying by the one-man system the cannoneer ~~is~~ was exposed in some positions of traverse.

When it was necessary to traverse the gun by moving the trails to engage a new target, 35 seconds were required to get off the first round. In firing at low elevations the recoil pressure on the spades was such that, in the soil at Fort Bragg, the spades never seated. In firing tests the spades continued to back up two or three feet every ten rounds. Another adverse comment was that the carriage was too heavy for manhandling by a full gun squad even over short distances.

The Commanding General, Services of Supply, wrote the Requirements Division on 23 August 1942 asking that the development of the Cletrac Gun Motor Carriage be discontinued, ~~and~~ that development of the M10 (Gun Motor Carriage) be expedited, and that at least 500 3-inch antitank guns on the 105-mm howitzer carriage be produced before January first 1943. Rapid production of these guns placed them at the disposal of U.S. troops in the North African and Italian campaigns.

A 3-inch gun T10 and one 3-inch carriage T1 were shipped to Camp Hood, Texas for test by the Tank Destroyer Board, early in September of 1942. Rigorous tests were run for the balance of the year, resulting in definite ~~and resulted in the following~~ recommendations and comments. The trails with folding spades modeled after the spades on the German 105-mm howitzer carriage, were stated to be unsatisfactory. It was suggested that the drawbar be designed to work with the adopted prime mover so that the full maneuverability of the prime mover ~~may~~ could be used without cramping the spades into the towing vehicle. A further

modification suggested ~~placing~~ was that the bracket (ball and cup aligning mechanism) be placed on top of rather than below the trails.

Modification of the carriage included the following recommendations: "(1) That a cleat type foot rest be added on each side of the axle to prevent the gunner and number 1 from being unseated on displacement of the carriage in firing. (2) That a shoulder guard be placed on the cradle in such a manner that the gunner and number 1 can brace their bodies between the cleat and the carriage proper as a protection and steadying device while manipulating the traversing and elevating systems during the firing of the piece. (3) That the elevating gearing be improved to give smooth, even, operation. (4) That the interference which is noticeable 50 mils left of the extreme right traverse and becomes positive at 30 mils left of the extreme right traverse when the elevating handwheel handle is in the upper forward quarter be eliminated. (5) That the towing hooks on the axle be enlarged so that tow ropes can be easily attached. (6) That the hand brakes be modified to permit easy braking from either side of the shield. (7) That bar holds be provided to increase leverage on the wheels under exceptionally difficult circumstances."

A further suggestion proposed an ammunition ~~on~~ rack for ready rounds of a light weight "come-apart" type holding three pounds per tray, with the separate trays interchangeable and three trays provided for each weapon. This rack was to be designed by the Technical Branch of the Artillery Division. Recommendations were also made for a shield similar to the one devised by the Field Artillery Board for the 105-mm Howitzer M2.

By the beginning of December 1942, the engineering test of the 3-inch Gun T10 and Gun Carriage T1 had been completed at Aberdeen Proving Ground, and the gun and carriage were shipped to Fort Bragg for test by the Field

Artillery Board. The materiel had been standardized in the fall of 1941 before tests by the Service board, because the components had already been tested thoroughly with respect to the weapons for which they were originally designed; and it was necessary standardized also to expedite the production of one hundred units which had been ordered by the Adjutant General.

Experimental Traversing Mechanisms for 3-Inch Guns

To replace the rack and worm traversing mechanism, two types of screw traversing mechanisms for 3-inch antitank guns were developed: One unit was assembled with a rigid bracket, while the other was equipped with a swivel type bracket, were

Artillery Board. The materiel had been standardized in the fall of 1941 before tests by the Service Board, because the components had already been tested thoroughly with respect to the weapons for which they were originally designed; standardized also to expedite the production of one hundred units which had been ordered by the Adjutant General.

Initiation of Project for 76-mm Gun T2 and Carriage T3

In May of 1943 a letter from Headquarters, Army Ground Forces to the Commanding General, Army Service Forces, requested that a development project be initiated to place a 76-mm gun on a 105-mm howitzer carriage to replace the 3-Inch Gun M5. Designated 76-mm Gun T2, (the gun was to be rifled for 3-inch ammunition) and mounted on Gun Carriage T3. Gun Carriage T3 was the 3-Inch Gun Carriage M1 modified to take the 76-mm gun and Recoil Mechanism T34.

Take out and insert under 76 mm development

As originally conceived by General Devers, this weapon was to have a specific strategic function. The T2 gun was to be towed by a tank also mounting a 76-mm gun and using the same ammunition. The tank could then run into enemy terrain, and leave the antitank gun as a trap for enemy counterattack.

Six guns were made, four for pilot models and two for spares. They were sent to Aberdeen Proving Ground late in 1943 where Army Ground Force and Ordnance representatives were to compare their performance with that of the proposed T4 and T5 Carriages of alternate design, and with the German model, PAK 40. The project was suspended at this stage, and later canceled because rapid development of the T4 and T5 carriages together with the 76-mm T3 Gun showed more promise as a replacement weapon for the original 3-Inch materiel.

Experimental Traversing Mechanisms for 3-Inch Guns

To replace the rack and worm two types of screw traversing mechanisms, one assembled with a rigid bracket and the other with a swivel type bracket were

devised for use with 3-inch antitank guns. Both of these mechanisms were tested extensively by the Tank Destroyer Board. Each assembly was traversed 21 hours on slopes of 15°, towed 500 miles cross-country, and fired 30 rounds. Check for wear and backlash were made continuously throughout the tests.

Backlash, as measured by the amount the handwheel could be moved, changed from .05 (18°) to .1 (36°) on the bracket with the swivel in it, and from .04 (14.4°) to .06 (19.6°) with the rigid bracket. No evidence of binding was found in either mechanism. After wear tests, both were disassembled and inspected. There was slight stripping of babbitt metal in the form of thin shavings in each mechanism.

The rigid type proved to be best, for the swivel type developed more backlash and more wear in the babbitt thread of the nut. However, both mechanisms were serviceable, and no actual malfunctioning was experienced in the tests. The Tank Destroyer Board recommended that the bearing supported bracket be discontinued.

Experimental Hydraulic Elevating Mechanism

Although the standard pinion and arc elevating mechanism on the 105-mm Howitzer Carriage M2 was rugged it was only reasonably satisfactory because the moving parts could be clogged by sand, mud, dust and snow. To overcome this handicap development of a series of experimental hydraulic elevating mechanisms was started in 1941.

An attempt to improve upon the standard pinion and arc elevating mechanism on the 105-mm Howitzer Carriage M2, which was rugged but only reasonably satisfactory because sand, mud, dust and snow clogged the moving parts, was embodied in the development of a series of experimental hydraulic elevating mechanisms which was started in 1941. The (Myers-Haley) company made a gear-type pump made by an industrial facility, which was tested at Aberdeen early in 1942. Modifications of the pilot overcame all of the difficulties except an oil slippage inherent in that type of pump. Another design was made incorporating piston pumps, to which Rock Island Arsenal engineers added a valve which would isolate the firing load from the handwheels, but this did not prove acceptable and development was then turned over to the Franklin Institute in Philadelphia. By December 1942 Institute engineers were working on new designs which never

WHAT MODIFICATIONS?

What difficulties?

reached service tests.

In January 1943 all previous designs for hydraulic elevating mechanisms were dropped. Two new designs were worked on during 1943 and 1944, one in the Industrial Division and the other in the Technical Division of the Ordnance Department. The one developed by the Industrial ~~Service~~ Division at Rock Island Arsenal was tested in September 1943 by Aberdeen Proving Center, and in April 1944 by the Field Artillery Board. It was found to function satisfactorily. However it was not adopted because it did not function any better than the standard mechanism, because it was vulnerable to gunfire, and because it was difficult to replace oil that had leaked out in the field. Further development of a screw and nut type mechanism began in May 1943 but was abandoned, ~~as~~ for preliminary designs showed that the carriage would have to be completely redesigned to take the mechanism. A full record of this development appears in the 105-mm howitzer chapters.

Removable Auxiliary Spades, and Jointed Trails for 3-Inch Carriage M1

A development project to provide removable auxiliary spades for 3-Inch Gun Carriage M1 was initiated in March 1943. They were to be attached to the ~~present~~ existing fixed spade by a simple non-moving joint, and could be removed when weapons were to be towed or stored. Similar type spades tested on 105-mm Howitzer Carriage T6 (M3A1) did not come loose during firings in soft ground and rearward movement of the carriage was appreciably checked.

The 3-Inch Gun Carriage M1E1, so designated because of its modified trails which were of the jointed type for tests of suitability in airborne use, was to be tested by both the Field Artillery Board and the Airborne Command. These tests were to determine whether there was a requirement for transporting 3-inch gun carriages on current (or future) models of aircraft, and whether it was necessary to modify current carriage models for such airborne operations.

They were also to determine whether jointed trails were necessary, and if so, whether the type developed was satisfactory. Preliminary tests at Aberdeen Proving Ground indicated that the jointed trails were strong enough for use with the carriage and that they were satisfactory as to ease of assembly and disassembly. The carriage could be easily maneuvered by hand on hard level ground when the rear sections of the trails were removed.

At Fort Bragg tests included firing 15 rounds, movement of the weapon by hand with and without the rear trail segments, and tow test of 495 miles. The segmented trails functioned satisfactorily in firing and tow tests but the Board concluded that there was no need for segmented trails for Field Artillery use and recommended that no further consideration be given to the use of jointed trails for these weapons.

At Camp Mackall, the Airborne Command conducted loading tests in a mock-up of a C-46 plane, and found that the 3-inch carriage M1E1 could be loaded safely and efficiently when equipped with full length trails. Loading the carriage with half-length trails was neither easier nor faster. The recommendation followed that jointed trails need not be adopted for airborne use. This project was subsequently canceled.

A directive was issued for Service Board Test of the 3-inch Gun Carriage T2 by the Tank Destroyer Board in July 1943. A pilot had been assembled at Rock Island Arsenal which incorporated innovations resulting from recommendations of the Service Board after tests of the T1 carriage in the fall of 1942. The innovations and modifications to be considered were: 9.00-16 combat tires, standard 6.50 x 16 wheels with divided rims, new hubs, a new shoulder guard on the left side of the carriage, new shield (similar to those designed by the Field Artillery Board for the 105-mm Howitzer Carriage M2A2), the new location of the elevating and traversing handwheels, a foot rest on the axle on the left side between the wheel and trail, firing segments, a removable

caster wheel, an alternate set of experimental sloping shields designed and manufactured at General Bronze Corporation, and the following fire control items: Panoramic Telescope M12A3, Telescope T48 (on left) Telescope Mount M4lA2, Range Quadrant M6, Elbow Telescope M29. Desired changes were to be noted and incorporated in a standard carriage, and also applied to the M1 carriage under production for delivery to troops.

The model designations for the 3-inch Gun Carriage was to be M1A1 when the field modifications were incorporated in M1 carriages already manufactured. New carriages scheduled to be completed by the end of December 1943 were to be designated M6 and the model designation of the recoil mechanism for M6 and M1A1 Carriages was changed from M9 to M9A1 to identify those with 5-inch extensions.

By February 1, 1944 a letter accompanying the Tank Destroyer Board Report of the Service Test of the 3-inch Gun Carriage M6 enthusiastically endorsed the redesign of the M1 into the M6 Carriage, stating that it had resulted in an excellent towed tank destroyer weapon.

76-mm Tank Gun Development

In July 1942 the Ordnance Committee authorized the manufacture of two experimental gun tubes and 500 rounds of ammunition to increase the armor piercing characteristics of 3-inch guns. The 76-mm weapon (originally 3-Inch Gun T13) then used in medium tanks (M4) was put in a 75-mm breech ring. Both the chamber of the gun and the cartridge case for the projectile were redesigned. The breech ring and breech mechanism of the 75-mm tank gun M3 were incorporated in the design, resulting in a new gun capable of higher muzzle velocities.

Tests at Aberdeen Proving Center brought immediate approval of the new gun which was standardized 76-mm Tank Gun M1 in August 1942. The muzzle velocity of the M1 was 2,600 feet per second and the rated maximum

r 76m/m Gun T2 and Carriage T3

In May of 1943 a letter from Headquarters, Army Ground Forces to the Commanding General, Army Service Forces, requested that a development project be initiated to place a 76m/m gun on a 105m/m howitzer carriage to replace the 3-Inch Gun M5. Designated 76m/m Gun T2, and mounted on Gun Carriage T3.

~~was the 3-inch Gun Carriage M1 modified to take the 76m/m~~
Gun Carriage T3 was the 3-Inch Gun Carriage M1 modified to take the 76m/m gun and Recoil Mechanism T34.

As originally conceived by General Devers, this weapon was to have a specific ~~strategic~~ tactical function. The T2 gun was to be towed by a tank also mounting a 76m/m gun and using the same ammunition. The tank could then run into enemy terrain, and leave the antitank gun as a trap for enemy counterattack.

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Six guns were made, four for pilot models and two for spares. They were sent to Aberdeen Proving Ground late in 1943 where Army Ground Forces and Ordnance representatives were to compare their performance with that of the proposed T4 and T5 Carriages of alternate design, and with the German model, PAK 40. The project was suspended at this stage, and later canceled because rapid development of the T4 and T5 carriages together with the 76m/m T3 Gun showed more promise as a replacement weapon for the original 3-Inch materiel.

Application of Tank Gun to Towed Carriages

Meanwhile a new series of 76m/m guns was being developed from the M1E5 (M1A1) model tank gun, starting in August of 1943, for mounting on experimental carriages T4 and T5. These T3 guns and modified versions of the T3 type were to be tested extensively for antitank use. The breech operating mechanism for the antitank gun differed from that of the tank gun because the speed of semiautomatic operation conflicted with the slower counterrecoil needed for carriage stability. Hand operation was therefore provided.

The experimental carriage T4 was patterned after the (American-designed) 57m/m Gun Carriage T2 and weighed considerably less than the 3-inch

powder pressure 43,000 pounds per square inch. The effective volume of the new cartridge case was 147 cubic inches and the total weight of the AP projectile fifteen pounds. The ammunition was interchangeable among 76-mm tank guns, 76-mm antitank, and 76-mm tank destroyer guns.

Modifications of this basic design were made to secure the best balance on medium tank mounts. Modification M1E5, later standardized M1A1 was like the M1 gun but had longer recoil surfaces. Metallurgical tests on this model disclosed good impact values and high yield strength. In December of 1943, the M1A1 was supplanted by the M1A2 which differed from the former only in the manner of rifling. The steeper twist of 1/32 gave greater stability to the projectile than the original 1/40 of the M1A1 tube. The Ordnance Committee standardized the M1A2 (M1E6) with the addition of threads at the end of the tube for a muzzle brake. A ring was to be provided to cover the threads at installations where the brake was not used. M1A1 guns were classified limited standard at this time and were to be used by troops until replacements were necessary. Production of M1A1 types was curtailed and new orders placed for M1A2 guns only.

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The experimental carriage T4 was patterned after the (American-designed) 57-mm Gun Carriage T2 (later M1A3) and weighed considerably less than the 3-inch

Gun Carriage M6 or M1. The T5 was a new design and differed in type of traversing mechanism (a worm and spur gear on the T4, and a screw type mechanism on the T5 carriage), and also in the construction of the trails and spades. The T4, ~~was also to have~~ unlike the T5 which had neither, was equipped with wheel segments for firing and a drawbar. ~~The T5, neither.~~

At a conference on 3 June 1943 during a discussion of antitank weapons production and development programs were outlined for 1943 and 1944. The T3 gun and T5 carriage were considered most promising of the 76-mm antitank gun proposals, and at a second Aberdeen conference on 21 September 1943 the first experimental project (T2 Gun and T3 Carriage) was suspended. Formal cancellation followed in Ordnance Committee action 18 November 1943 and was approved 9 December.

The 76-mm Gun T3 was to supersede the 3-Inch antitank gun M1 and to be rifled with a twist of 1 turn in 32 calibers (Dwg. D69297, Revision 3, 21 May 1943) like the 76-mm Gun M1A1, which, under test was reported to have improved dispersion because of the steeper twist. The tube was to be threaded according to Ordnance Sketch TARC 55, revision of 19 August 1943 for a muzzle brake. Firing the same ammunition as the 76-mm M1A2, the T3 would penetrate heavier armor than the 75-mm gun. Two pilots were begun in September 1943 and shipped for service board tests in January 1944.

The Tank Destroyer Board at Fort Knox issued a preliminary report comparing the 76-mm T4, T5, and 3-Inch M6 carriages on 19 January 1944. Manhandling difficulties were about the same for all three carriages on level ground despite the 1500 pound difference in weight between the M6 and the newer experimental carriages. The lack of greater speed in the case of the T4 and T5 carriages was attributed to the smallness of their wheels. (Radius of M6 wheels, 19 inches; radius of wheels on T4 and T5, 15 inches.)

Up inclines the T4 and T5 were easier to handle, but the T5 took longer to prepare for action, 40 seconds as against 32 for the T4, and 35 seconds for the M6. This is because the wheels on the T5 have to be jacked. Relative heights: T4 - 51 inches, T5 - 48 inches, M6 - 61 inches, show that the T4 and T5 have better silhouettes for concealment than the M6.

A number of prime movers were tested. The ¼-ton and 1½-ton trucks were not suitable. The 2½-ton truck was better but not as satisfactory as a half-track in mud and rough cross country operations. The half-track was satisfactory on ordinary terrain for any of the three guns, and could tow the T4 and T5 up 50% grades. Muzzle clearance of the M6 was considerably greater than that of the T4 or T5 and this was a distinct advantage in crossing ditches. (Clearance of M6 - 64 inches, T5 - 55 inches, T4 - 29 inches). The muzzles of the T4 and T5 dragged, and the muzzle brakes filled with dirt although no damage was noted. Both the T4 and T5 carriages rode more smoothly than the M6 which bounced on all terrain including concrete road.

During firing tests the recoil and counterrecoil action was normal, and stability satisfactory. The sighting equipment was not satisfactory, direct sight T117, proving inferior to the T108 on the 3-Inch Gun Carriage M6.

Two ejector cams one fast and one slow, were provided for the T5 carriage. The slow action was successful but the fast cam threw the cartridge 30 to 40 Feet ~~yards~~.

Traveling loaded the firing jacks on the T5 with mud and grit. They jammed frequently and could not be cleaned properly in the field. Complete disassembly was often needed to free the mechanism, and effective lubrication was impossible.

The fixed spades on the T4 carriage were not desirable. In traveling position the high coupling at the towing pintle forced the muzzle too close

to the ground where clearance was not sufficient to begin with. The caster on both T4 and T5 carriages frequently dragged through the mud instead of rolling. The small diameter of the wheel and the small size of the tire were responsible for this difficulty.

Recommendations suggested that development continue on both T4 and T5 carriages. The T4 was to be provided with increased muzzle clearance, ~~reduced~~ was to be reduced trail weight, improved firing mechanism, ~~increased~~ was to be increased wheel size, and the sighting equipment was to be that used with the M6 carriage. The T5 was to be developed on an experimental basis to obtain further knowledge and overcome the defects found in the preliminary tests. The Board added that if only one type carriage could be continued, the T4 was more desirable at that stage. A muzzle brake was necessary, the report concluded, for more efficient blast control. How did they differ?

Gun designations T3E1 and T3E2 were given to differentiate between guns equipped with the two types of breech operating cams, one type made by Watervliet and the other by a private manufacturer (Oldsmobile). A third modification, T3E3, had a 76-mm tube threaded to take a muzzle brake. This pilot had a semiautomatic breech with a spring coupled actuated arm. One pilot was held by the Tank Destroyer Board for extended service tests, and engineering tests were made on the other T3E3 gun at Aberdeen. all T3 had MB # T3E3

Carriage designations T4E1 and T5E1 were to apply to the experimental pilots after the modifications recommended by the Tank Destroyer Board had been made.

Results of further testing by the Tank Destroyer Board appeared in a full report on Project No. 205, "76-mm Gun Carriages T4E1 and T5E1," dated 31 May 1944. In comparative tests with 3-Inch Gun M5 on 3-Inch Gun Carriage M6 the muzzle brakes effectively dispersed smoke. However, both muzzle brakes worked loose during firing and had to be secured by drilling and tapping for

set screws 180° apart. When firing over dust, both guns raised a large dust cloud obscuring the target for an average of 11.3 seconds between rounds. The rate of fire, established without dust hazards, was 8 1/3 seconds for the T5E1, and 8 1/2 seconds for the T4E1. The limiting factor was sight clearance rather than mechanical functioning.

The T5E1 carriage was not stable, the cradle and gun were loose on the carriage. The T4E1 showed slight superiority to the T5E1, both were superior to the M6, and easier to handle. Neither gun bounced behind the prime mover when towed with a 30-foot tow rope.

Continuing tests for the most satisfactory prime mover, the M3 half-track remained best on firm ground, but bogged in mud. The 3/4-ton and ¼-ton truck were good only on firm terrain, and the Gun Motor Carriage M18 was too powerful. Most satisfactory for all round use were the 2½-and 1½-ton trucks. Final selection between the latter awaited further tests.

The T4E1 fired as well on tires as on wheel segments, the equalizer on the axle compensating for unevenness of the terrain. For firing stability both trails of the T5E1 were dug in to the same plane with the wheels, and for maximum range the T5E1 was dug in 4 inches and needed a recoil pit one foot deep. One and a half hours were needed to emplace the gun.

Both weapons were ballistically accurate. The effect of muzzle blast on the gunner and gunner's sight was found to be inversely proportional to the elevation of the tube. Blast effect was heavier on the ears of the gunner firing the T4E1 than for the gunner firing the T5E1. The slope and extent of the shield was responsible for increased blast. On the T5E1 carriage where the side shield made a smaller angle with the front section, and extended farther back, blast was noticeably smaller. Without shields the blast increased in both cases.

Recommendations after these tests were substantially the same as those after the preliminary test of the new carriages. The muzzle brake was to be improved for more effective blast control, the proposed sighting equipment was to be replaced with that used on the 3-Inch M6 carriage, and minor changes were suggested to correct difficulties encountered during the test program. These included a lock on the muzzle brake, the adoption of larger wheels, increased muzzle clearance and tow ropes such as those used during tests for manhandling.

Because neither weapon was entirely satisfactorily still another experimental carriage (T7) was developed. This carriage was to incorporate the changes suggested by the Tank Destroyer Board in their recommendations after testing the T4E1 and T5E1 types. Design progress proceeded under low priority,

The T7 was to be equipped with a new telescope and mount, (Telescope T129 and Mount T71), which was an adaptation of the optical system of telescope T116 to a more compact and balanced mounting arrangement. To eliminate interference the new T71 mount held Telescope T129 pendulum fashion by a pair of trunnions with axes parallel to the gun breech. A cross leveling mechanism acted about the trunnions and held the telescope at the bottom. Vertical and horizontal bore sighting adjustment was accomplished by a worm with bolted locking clamps. Manufacture of the pilot model was started in the fall of 1944 and ~~delivery~~ manufacture was completed on 27 June 1945. The weapon was shipped to Aberdeen Proving Ground for Engineering tests on 1May 1945. The Engineering tests were completed and the weapon found to be satisfactory; it was then shipped to Army Ground Forces Board No.2 Fort Knox Ky. for service test. Services test were cancelled by Army Ground Forces due to lack of requirement for 76m/m towed Guns. Termination by OCM Action of this project is now underway.

Muzzle Brakes

Several muzzle brakes were under development during 1943 to decrease the piston rod pull in recoil as the light T3, T4, and T5 carriages were relatively unstable (when the power of the original 76m/m gun was increased.) The Most

promising brake was the double baffle type which absorbs approximately half of the recoil energy, and higher efficiency would produce too great pressure at the gunners position causing extreme discomfort to the gun crew. Experimental work and research continued until the T8 brake, modified to require a minimum of machining was standardized and designated M2 in April 1944. The double baffle M2 reduced recoil 50% and channeled blast effectively. The steel was cast to the desired internal dimensions and only the vital exposed surfaces machined. This method of manufacture has resulted in a 3-pound weight reduction. Another experimental double baffle brake of forged aluminum was tested but could not withstand the heat of firing or the corrosive effect of gases.

A new primer, 19 inches long and designed for front ignition was used with powder containing no potassium sulfate. This combination eliminated high pressures and flash when fired in a gun without a muzzle brake. Made of brass tubing with vents only in the forward portion of the tube, the percussion Primer M40 greatly reduces the amount of smoke produced. (Muzzle brake and gas deflector development is recorded in a separate section of this record. The M40 Primer is discussed in detail in the Ammunition Volume (s).) ~~(INCOMPLETE. These 76-mm AT projects are slow, but not officially closed.)~~

3-Inch Gun T10 3-Inch Gun Carriage T1

Gun Tube

Caliber----------3-Inch

Length, bore----------50 Calibers

8 Gun tube (or Overall)----------158-inches

Weight----------1600 lb.

Rifling, number of grooves------

Twist----------1 turn in 25 calibers; Uniform, right hand

Pressure, maximum----------34,000 Lb./Sq. In.

Range (APC M62)----------16,100yds.

Recoil Mechanism

Model----------M9A1

Type----------Hydrpneumatic

Recoil at 0^{0} elevation----------30½ in.

At maximum elevation----------44 in.

Gun Carriage

Model----------T1
Elevation Maximum----------30 degrees
Elevation, Minimum---------- -5 degrees
Handwheel effort to depress or elevate------ lb.
Traverse----------22½ degrees right
22½ degrees left
Handwheel effort to traverse---------- Lb.
Length in traveling position----------278 in.
Width in traveling position----------82 in.
Road clearance----------15½ in.
Weight----------5,109 lb.
Tires----------9.00X20
Equilibrator, type----------Spring
Cartridge rammer, model----------
Type----------

YPICAL CHARACTERISTICS

3-Inch Gun M5 3-Inch Gun Carriage
M6

Gun Tube

Caliber	3-Inch
Length, bore	50 Calibers
Gun tube (or Overall)	158 in.
Weight	1600 lb.
Rifling, number of grooves	28
Twist	1 turn in 40 calibers; uniform, right hand
Pressure, maximum	34,000 lb./sq.in.
Range	12,000yd.

Recoil Mechanism

Model	M9 and M9A1
Type	Hydrpneumatic
Recoil at) 0° Elevation	32 in.
At maximum elevation	44 in.

Gun Carriage

Model	M6
Elevation, Maximum	30 degrees
Minimum Elevation	-5 Degrees
Handwheel effort to depress or elevate	
Traverse	23 degree right 23 degree left
Handwheel effort to traverse	
Length in traveling position	278 in.
Width in traveling position	85 in.
Road clearance	15½ in.
Weight	5,720 lb.
Tires	9.00X20
Equilibrator, type	Spring
Cartridge rammer, model	
Type	

3-Inch Antitank Gun M5, Carriage M1

Gun Tube

Caliber	3-Inch
Length, bore	50 calibers
Weight	1,475 lb.
Gun tube (overall)	158.4 in.
[illegible]	1 turn in 40calibers
Twist	Uniform, right hand
Pressure, maximum	34,000 lb.
Rifling, number of grooves	24

Recoil Mechanism

Model	M9
Type	Hydropneumatic
Recoil at 0 degree elevation	30.5in.
6 At maximum elevation	44 in.

Gun Carriage

Model	M1
Elevation, maximum	30 degree
Elevation, minimum	-5 degree
Handwheel effort to depress or elevate	
Length in traveling position	278 in.
Width in traveling position	82 in.
Handwheel effort to traverse	
Road clearance	15½ in.
Weight	5,109 lb.
Tires	9.00 X 20
Equilibrator, Type	Spring
Cartridge rammer, model	
Type	

TYPICAL CHARACTERISTICS

75m/m Gun M3 75m/m Howitzer Carriage M3A1

Gun Tube

Caliber	75m/m
Length, bore	37.5 Calibers
Gun tube (Overall)	118 in.
Weight	910 lb.
Rifling, number of grooves	24
Twist	1 turn in 25.223 calibers Uniform, right hand.
Pressure, maximum	36,000 lb./sq. in.

Recoil Mechanism

Model	M1
Type	Hydrospring
Recoil at 0 degree elevation	11.62 in.
At maximum elevation	14 in.

Gun Carriage

Model	M3A1
Elevation, maximum	30 degree
Elevation, minimum	-9 degree
Handwheel effort to depress or elevate	
Traverse	22½ degree right 22½ degree left
Handwheel effort to traverse	
Length in traveling position	152½ in.
Width in traveling position	67¼ in.
Road clearance	10 in.
Weight	2,160 lb.
Tires	8.00 X 16
Equilibrator, type	Spring
Cartridge rammer, Model	
Type	

TYPICAL CHARACTERISTICS

75-m/m Gun M1897A2 and Carriage M2A3

Gun Tube

Caliber	75 m/m
Length, Bore	34.5 Calibers
Gun tube ----------(Overall)	107 in.
Weight	1,026 lb.
~~Rifling, number of grooves~~	1 turn in 25.586 calibers
Twist	Uniform, right hand.
Rifling, number of grooves	24
Pressure, maximum	36,000 lb./sq. in.

Recoil Mechanism

Model	M1897A7, M2A2-3
Type-	Hydropneumatic
Recoil at 0 degree elevation	44.9 in.
At maximum elevation	48 in.

Gun carriage

Model	M2A3
Elevation, maximum	45½ degree
Elevation, minimum	-10 degree
Handwheel effort to depress or elevate	
Traverse	30 degree right 30 degree left
Handwheel effort to traverse	
Length in traveling position	~~220.5 in~~. 220.5 in
Width in traveling position	82 in.
Road Clearance	15 in.
Weight	2,081 lb.
Tires	7.50 X 24
Equilibrator, type	Spring
Cartridge Rammer, model	
Type	

TYPICAL CHARACTERISTICS

76m/m Gun T2 Carriage T3

Gun Tube

Caliber	76m/m
Length, bore	52 calibers
Gun tube (overall)	163.75 in.
Weight	1,193 lb.
Rifling, number of grooves	28
Twist	1 turn in 40 calibers Uniform, right hand
Pressure, maximum	43,000 lb./sq.in.
Range	14,000 yds.

Recoil Mechanism

Model	T34
Type	Hydropneumatic
Recoil at 0 degree elevation	32 in.
Maximum elevation	44 in.

Gun Carriage

Model	T3
Elevation, maximum	45 degree
Evelation, minimum	-5 degree
Handwheel effort to depress or elevate	25 lb.
Traverse	27.5 right 27.5 left
Handwheel effort to traverse	lb.
Length in traveling position	280 in.
Width in traveling position	85 in.
Road clearance	15½ in.
Weight	6,115 lb.
Tires	9.00 X 20
Equilibrator, type	Spring

TYPICAL CHARACTERISTICS

76m/m Gun T3 Carriage T4E2

Gun Tube

Caliber		76m/m
Length, bore		52 calibers
Gun tube	(Overall)	163½ in.
Wight		1,230 lb.
Rifling, number of grooves		28
Twist		1 turn in 40 calibers Uniform, right hand
Pressure, maximum		43,000 lb./sq. in.
Range		14,000 yds.

Recoil Mechanism

Model	T32
Type	Hydropneumatic
Recoil at 0 degree elevation	28½ in.
Maximum elevation	32 in.

Gun Carriage

Model	T4E2
Elevation, maximum	20 degree 20 min.
Elevation, minimum	-8 degree
Handwheel effort to depress or elevate	6 lb.
Traverse	30 degree right 30 degree left
Handwheel effort to traverse	8 lb.
Length in traveling position	259 in.
Width in traveling position	81½ in.
Road clearance	11½ in.
weight	4,375 lb.
Tires	8.00 X 16
Equilibrator, type	*****

TYPICAL CHARATERISTICS

76m/m Gun M1 Gun Carriage T6

Gun Tube

Caliber	76 m/m
Length, bore	52 calibers
Gun tube (Overall)	163½ in.
Weight	1,193 lb.
Rifling, number of grooves	28
Twist	1 turn in 32 calibers; Uniform, right hand
Pressure, maximum	43,000 lb./sq. in.
Range ~~44,000~~	14,000 yds.

Recoil Mechanism

Model	T32
Type	Hydropneumatic
Recoil at 0 degree elevation	19 in.
Maximum elevation	33 in.

Gun Carriage

Model	T6
Elevation, maximum	15 degree
Elevation, minimum	-10 degree
Handwheel effort to depress or elevate	20 lb.
Traverse	30 degree right 30 degree left
Handwheel effort to traverse	10 lb.
Length in traveling position	263 in.
Width in traveling position	76½ in.
Road clearance	11.375 in.
Weight	3,410 lb.
Tires	7.50 X 16
Equilibrator, Type	****

TYPICAL CHARATERISTICS

76m/m Gun T3E3 Gun Carriage T7

Gun Tube	
Caliber	76m/m
Length bore	52 calibers
Gune tube (Overall)	156 in.
Weight	1145 lb.
Rifling, number of grooves	28
Twist	1 turn in 32 calibers; Uniform, right hand.
Pressure, maximum	42,000 lb./sq. in.
Range	14,000 yds.
Recoil Mechanism	
Model	T32E1
Type	Hydropneumatic
Recoil at 0 degree elevation	29 in.
Maximum elevation	32 in.
Gun Carriage	
Model	T7
Elevation, maximum	25 degree
Elevation, minimum	-7 degree
Handwheel effort to depress or elevate	5 lb.
Traverse	30 degree right 30 degree left
Handwheel effort to traverse	9 lb.
Length in traveling position	245½ in.
Width in traveling position	80½
Road clearance	12½ in.
Weight	4,088 lb.
Tires	9.00 X 16
Equilibrator, type	****

REFERENCES

B TM 9-322, "3-Inch Gun M5 and 3" Gun Carriage M1, "8 March 1943.

A TM 9-2300, Standard Artillery & Fire Control Materiel War Department, Washington, D. C., 7 February 1944.

A OCM 14477, 5 May 1938, recommends shield types for 75-mm Gun Carriages M2, M2A1, and M2A2.

A OCM 14510, 26 May 1938, recommends modifications to M1897, 75-mm field guns, and designations M1897A2 and M1897A4.

A OCM 16240, 7 November 1940, modifies shield for 75-mm Gun Carriage M2A3, recommending port in right side for elbow telescope T14E1.

B OCM 16368, 27 December 1940, proposes military characteristics for 3-Inch antitank gun and carriage. Approved by OCM 16517, 27 February 1941.

A OCM 16640, 24 April 1941, adopts 75-mm Gun T7 as standard with model designation 75-mm Gun M2, for medium tank M3. OCM 16741 approves Item 16640.

A OCM 16910, 26 June 1941, recommends standardization of 75-mm Tank Gun M3.

B OCM 17251, 18 September 1941, recommends modification of 105-mm Howitzer Carriage M2 for 3-Inch Gun Carriage T1.

B OCM 17285, 2 October 1941, recommends adoption of combat tires and divided rims as standard for Ordnance combat vehicles. Approved by OCM 17341, 16 October 1941.

B OCM 17407, 6 November 1941, changes classification of 3-Inch experimental antitank gun and carriage to standard types. Approved by OCM 17545, 17 December 1941.

B OCM 17944, 19 March 1942, initiates project for Gas Deflectors or Muzzle Brakes for 57-mm Gun T2.

B OCM 17974, 26 March 1942, approves application of combat tires for 105-mm Howitzer Carriage M2 and 3-Inch Gun Carriage M1.

B OCM 18198, 14 May 1942, directs test of Gas Deflectors T10, M5, M6, and T12 (Sketch AD-C 544) for 3-Inch Guns.

A OCM 18490, 16 July 1942, recommends development of gas deflectors for M2 and M3, 75-mm tank guns. Approved by OCM 18601, 6 August 1942.

C OCM 18503, 16 July 1942, authorizes the manufacture of two 76-mm Gun tubes T1 and 500 rounds of ammunition for test.

A OCM 18589, 6 August 1942, recommends the development of gas deflectors for 75-mm Guns M1897A3 and M1897A4.

C OCM 18650, 20 August 1942, standardizes T1 as 76-mm Tank Gun M1. OCM 18865, 10 September 1942, approves OCM 18650.

B OCM 18980, 10 September 1942, recommends adoption of adjustable trail traveling locks for 105-mm Howitzer Carriage M2.

B OCM 19192, 19 November 1942, recommends modified trail locking pins for 105-mm Howitzer Carriage M2 and for 3-Inch Gun Carriage M1.

B OCM 19383, 24 December 1942, directs testing of gas deflectors for 3-Inch Guns by Tank Destroyer and Desert Warfare Boards.

A OCM 19521, 14 January 1943, records engineering studies with 75-mm guns to determine characteristics of a proposed combination of components.

B OCM 19599, 28 January 1943, approves continuation of development project for experimental trails and spades on 105-mm Howitzer Carriage M2 and 3-Inch Gun Carriage M1 as recommended by Army Ground Forces, Field Artillery Board, and Tank Destroyer Board. Approved by OCM 20046, 25 March 1943.

B OCM 19809, 23 February 1943, approves new development project for improved spades for 105-mm Howitzer Carriage M2 and 3-Inch Gun Carriage M1.

B OCM 20027, 9 March 1943, directs test of 3-Inch Gun M5 on 3-Inch Gun Carriage M1 by Tank Destroyer Board, Desert Warfare Board, and Winter Detachment. Approved by OCM 20134, 8 April 1943.

B OCM 20045, 25 March 1945, approves policy pertaining to shields for field artillery weapons.

B OCM 20296, 29 April 1943, recommends 37-mm Sub-Caliber Mount for 3-Inch antitank guns and carriages.

B OCM 20472, 20 May 1943, gives military characteristics and status of development projects for caliber .22 subcaliber training rifle T5 and caliber .30 subcaliber rifle, T6 for 3-Inch Guns M5 and M7. Approved by OCM 20790, 17 June 1943.

B OCM 20793, 17 June 1943, records shipment of 3-Inch Gun M5 and Gun Carriage M1 to Armored Force Board for test.

B OCM 20844, 24 June 1943, records test results of screw traversing mechanism on 3-Inch Gun Carriage M1 by Tank Destroyer Board.

B OCM 21173, 29 July 1943, directs test of jointed trails on 105-mm Howitzer and 3-Inch Gun Carriages M2E4, and M1E1 by Field Artillery Board and the Airborne Command.

B OCM 21174, 29 July 1943, directs service test of 3-Inch Gun Carriage T2 by the Tank Destroyer Board.

B OCM 21209, 5 August 1943, records results of tests of gas deflector (AD-C 544) by Tank Destroyer Board, with additional recommendations. Approved by OCM 21455, 2 September 1943.

C OCM 21329, 19 August 1943, approves the development of 76-mm antitank Gun T3 will experimental breech mechanism and threaded muzzle instead of the 75-mm antitank gun.

C OCM 21382, 26 August 1943, approves the development of 76-mm Carriage T4 with list of military characteristics. Approved by OCM 21558, 16 September 1943.

C OCM 21383, 26 August 1943, approves development of 76-mm Carriage T5 and gives military characteristics. OCM 21558, 16 September 1943 approves OCM 21383.

A OCM 21636, 23 September 1943, cancels the development project for 75-mm Gun T14, 75-mm Gun Carriage T16 and Recoil Mechanism T31.

B OCM 21870, 21 October 1943, recommends modification of 3-Inch Gun Carriage M1 to M1A1, and standardization of Gun Carriage M6 for 3-Inch Gun M5; and also assigns designations 76-mm Gun T2 and 76-mm Carriage T3 to modified 3-inch antitank materiel for experimental antitank weapon. Approved by OCM 22132, 18 November 1943.

C OCM 22058, 11 November 1943, approves the change in twist of rifling from 1/40 to 1/32 for 76-mm Guns M1A1, M1A2, and T3.

C OCM 22110, 18 November 1943, cancels project developing 76-mm Gun T2 and Carriage T3. Approved by OCM 22316, 9 December 1943.

B OCM 22164, 4 November 1943, recommends cancellation of development project for gas deflectors for 3-Inch Guns M5 and M7. Approved by OCM 22434, 23 December 1943.

B OCM 23106, 9 March 1944, recommends cancellation of requirement for joined trails on 3-Inch Gun Carriage M1E1 and 105-mm Howitzer Carriage M2E4. Approved by OCM 23266, 23 March 1944.

B OCM 23804, 11 May 1944, records decision that apron shields are not to be applied to 3-Inch Gun Carriages M1A1, and M6.

B OCM 24049, 8 June 1944, recommends cancellation of project for auxiliary removable spades for 3-Inch Gun Carriages M1A1 and M6. Approved by OCM 24198, 22 June 1944.

B OCM 25164, 21 September 1944, recommends cancellation of development project for 3-Inch Guns T14 and T16, and 3-Inch Gun Carriage T5, and recommends conversion to original status of 90-mm Gun Carriage T9 for 90-mm Guns T13. Approved by OCM 25406, 12 October 1944.

B OCM 25590, 2 November 1944, classifies 3-Inch Gun Carriages M1 and M1A1 as obsolete types recommending conversion of all existing 3-Inch Gun Carriages to M6 type.

B O.O. 472.93/254 - Memorandum, 4 October 1940, Captain Weyher to General Barnes submitting preliminary layout of 3" Antitank Gun and Carriage (Drawing OMcF 2725)

B O.O. 472.93/297, Memorandum, 11 October 1940, Artillery Division, Industrial Service to Artillery Division, Research Staff, reconstruction of 3" Antitank Gun and given military characteristics.

B O.O. 472.93/658, 3 January 1941, Chief of Ordnance to Adjutant General, received approval of military characteristics in OCM 16368, 27 December 1940.

B O.O. 472.12/398 (c), 15 June 1943 , discusses heavy antitank gun production.

A O.O. 472.12/6673 (472/228, 21 August 1943, GNRQT-r/51221) forward to the Chief of Ordnance by the 1st Indorsement SPRMD 472, 21 August 1943, dated 25 August 1943 stating that the development project of 75-mm antitank gun be discontinued.

B Memorandum, 10 February 1944, from Chief of the Ballistic Section to the Chief of the Technical Division, Technical Division describes development of muzzle brake and P.A. Special 19-inch primer for 3-inch and 76-mm Guns, and outlines test program for this materiel.

B Aberdeen Proving Ground, "First Report on Test of 3-Inch Gun T10, 3-Inch Recoil Mechanism T5, Carriage T1 and First Report on Ordnance Program No. 5615, "7 May 1942.

B Aberdeen Proving Ground, "First Report on Test of German Muzzle Brake on 3-Inch Gun M5, Carriage M1, and Fifth Report on Ordnance Program No. 5888". 1 December 1942.

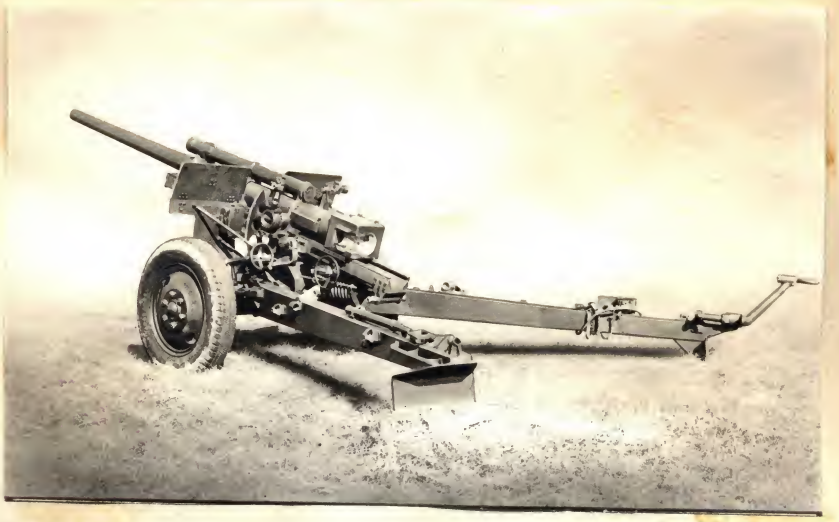
B Aberdeen Proving Ground, "First Report on the Development and Test of Modified wheels (9.00 x 16) and Firing Segments Assembled to 3-Inch Gun Carriage M1, and 147th report on O.P. No. 5229," 21 August 1943.

C Tank Destroyer Board, Preliminary Report on Project No. 205, "Test of 76-mm Gun Carriage T4E1 and T5E1," 19 January 1944.

C Tank Destroyer Board, Report on Project No. 205, "Test of 76-mm Gun Carriage T4E1 and T5E1," 31 May 1944.

3-Inch Gun T10 on
3-Inch Gun Carriage
T1, with recoil
mechanism T5

TD 1089



3-Inch Gun T10
3-Inch Gun Carriage T1
Recoil Mechanism T5

TD 1240

3-Inch antitank Gun M5
on 3-Inch Gun Carriage M6
with Recoil Mechanism M9A1

TD 1395

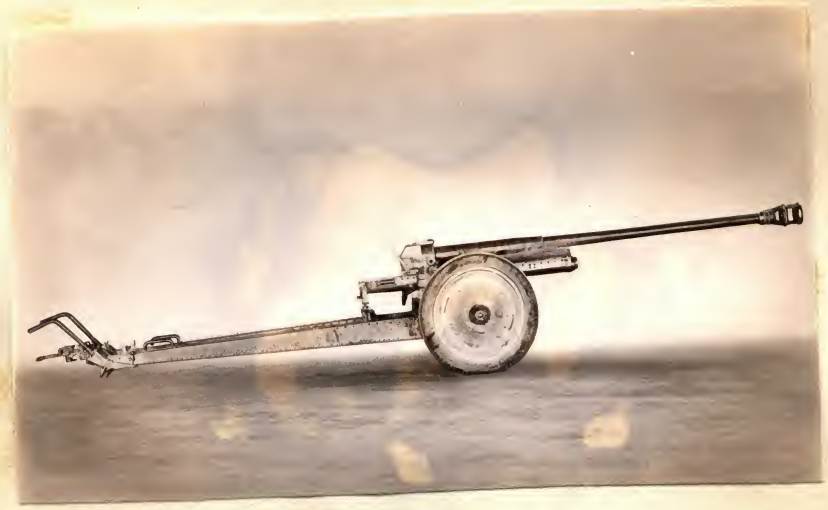
TD 554

3-Inch Gun Carriage M1 with experimental trails for airborne operations

TD 685

3-Inch Gun M7 (T12), right side showing breech closed

GERMAN ANTITANK GUNS



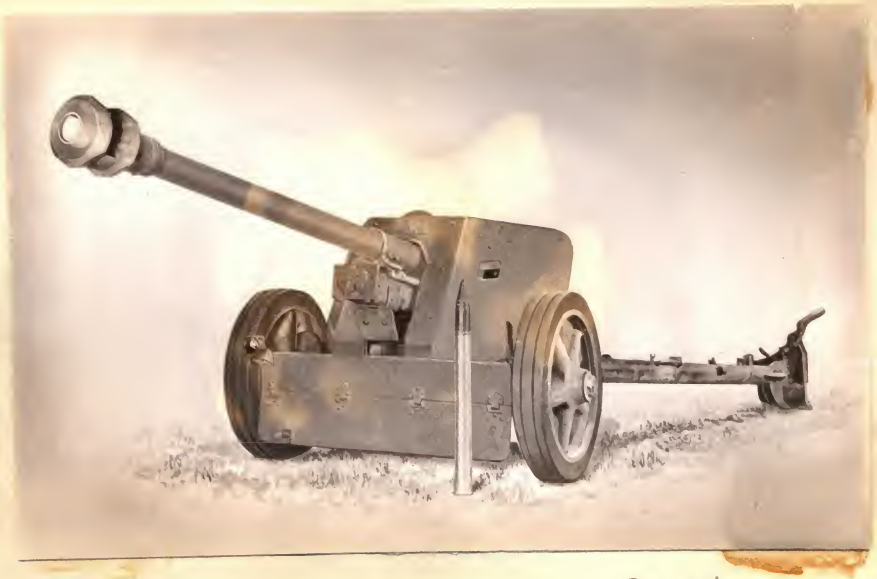
FM 31

7.62 cm. (3-inch) Pak 36

FM 104

7.62 cm. F.K. 39 (Ex-Russian)

GERMAN 75-mm ANTITANK GUNS



FM 14

7.5-cm. Pak 40 (2.95-inch)

FM 58

7.5-cm. Pak 97/37 (Ex-French)

TD 251

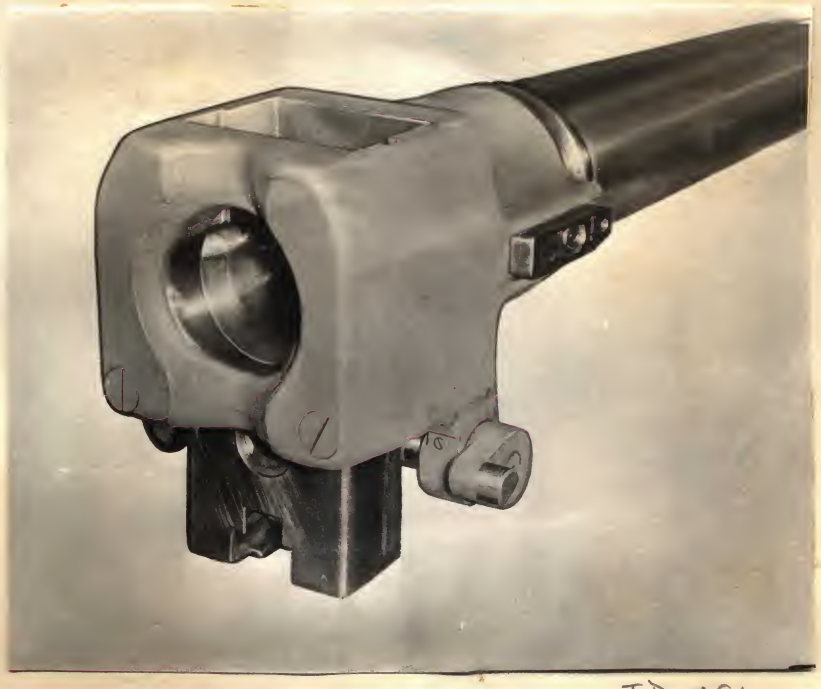
75-mm Field Howitzer Carriage M3A1 with 75-mm Tank Gun M3

TD 268

75-mm Tank Gun M3 on 105-mm Howitzer Carriage T6

TD 1271

75-mm Tank Gun M2 -- M3

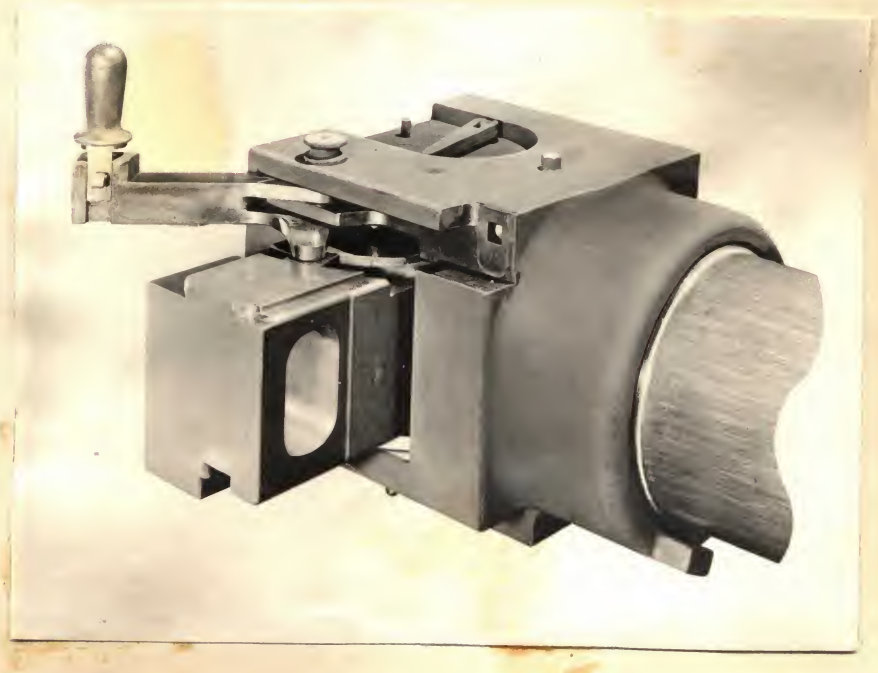


TD 691

75-mm Gun T9, right side showing breech open

TD 690

76-mm Gun T2, general assembly showing right side



TD 689

76-mm Gun T2, right side showing breech open

TD 1237

76-mm Gun T1, No. 2, (manufactured by Watervliet Arsenal, after modification of removing 5 calibers from length.)

(no print available yet)

TD 1108

76-mm Gun M1A1 (M1E4-M1E5) with 76-mm tube

76-mm Gun M1 assembled to 57-mm Gun Carriage T6 in limbered position (with German muzzle brake)

TD 152

76-mm Gun M1, on modified 57-mm Gun Carriage T2 (T6), with German single baffle muzzle brake.

TD 151

76-mm Gun Carriage T5E1, No. 2

TD 2271

90m/m ANTITANK GUNS & CARRIAGES

Development of 90m/m antitank materiel falls logically into two distinct phases. The first resulted in a weapon similar to the 3-inch Antitank gun but with a natural increase in weight and strinking power. (At the time the 3-inch gun was under development it was considered an expedient solution of an immediate requirement, but the need for greater firepower was recognized and by December of 1942 preliminary studies for a 90m/m antitank gun had been made.) The second phase starting early in 1944 was concerned with weight reduction and increased muzzle velocity. This development ran paralledl with the light weight, high velocity 76m/m development of the T3 Gun, T4 and T5 Carriages and was executed by the same group of Ordnance engineers.

90m/m Antitank Gun and Carriage Development

In recognition of the tactical need for greater fire power than that provided by the 3-inch Gun in antitank operations, work was initiated in 1942 to provide an antitank carriage for the antiaircraft 90m/m Gun M1. Preliminary calculations indicated that the originally proposed combination of M1 Gun and 105m/m Howitzer Carriage M2A1 would be impracticable. Consequently studies were initiated on a new weapon to use the same ammunition and obtain the same muzzle velocity (2650 ft/sec.) as the M1 Gun.

The 90m/m Gun M1 and the 105m/m Howitzer Recoil Mechanism M2 were modified and redesignated 90m/m Gun T8 and Recoil Mechanism T25 to adapt them to a new carriage designated 90m/m Gun Carriage T5. Preliminary studies immediately showed that the conventional type of carriage would result in an extremely long towing load, subject to all the difficulties of dragging the muzzle when crossing ditches. It was, therefore, decided to disconnect the trails and re-attach them to the muzzle end of the carriage for road travel. To further shorten the load, the trails were jointed and the spade end folded back for traveling position. The carriage further differed from the conventional in the use of an "X" type traverse bearing and a common gear box for elevating and

o give better handwheel operation. The forward end of the trails was locked to the trails for traveling.

The T5 Carriage was delivered to Aberdeen Proving Ground in January, 1944 for Engineering Test. It was found that the difficulties in manipulating the trails and the increased weight caused by the removable fittings and joints of the trails made the weapon impracticable.

The T5 Carriage was redesign and redesignated 90m/m Gun Carriage T5E1 to incorporate conventional type trails and effect an overall weight reduction. Delivery of the T5E1 Carriage to Aberdeen Proving Ground for Engineering Test was made in June, 1944; As plans for production of 600 weapons advanced, Aberdeen Proving Ground reported, that the T5E1 carriage had failed during cross-country tests. Fracture and deformation of the axle, cradle, top carriage, and of the trails at the lunette support occurred. It was obvious that the carriage ~~was~~ needed strengthening before going into production. However, the gun and carriage successfully withstood all stresses due toexcess pressure firing. The weakness in the carriage structure was attributed to the steel used in fabrication. This material was admittedly inferior in yield strength but a readily available stock was used to speed production after the designers' assurance that proper heat treatment would raise the yield strength to approximately 60,000 to 65,000 pounds per square inch.

At this time Headquarters, Army Ground Forces, Development Division, Requirements Section requested that the 90m/m Gun T8 on 90m/m Gun Carriage T5E1 be equipped with a muzzle brake ~~for~~ , but because this would require a re-design ofmuch of the carriage, it was decided to correct the structural weaknesses of the T5E1 carriage, changing the model designation to T5E2 and release the carriage for limited procurement. These changes threw production off schedule, and the original 600 weapons ordered under limited procurement requirements for delivery on or before 31 December 1944 ~~was~~ were reduced to 200. Three pilots incorporating the new modifications were manufactured for Aberdeen Proving Ground and Tank Destroyer Board tests ~~in order~~ to establish final characteristics. One gun of the three pilots was equipped with a M3 Muzzle brake to obtain a comparable test of muzzle blast with and without muzzle brake.

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Characteristics of the 90-mm Gun T8 and Carriage T5E2 when offered for limited procurement were briefly as follows: The tube was rifled with a uniform right hand twist, and tapered from the shoulder to the collar near the middle of the tube. The collar locked the forward yoke attaching the recoil mechanism to the tube in position. Forward of the collar the tube section was straight, and was not threaded for a muzzle brake.

The breech ring and breech recess were rectangular, the rear wall of the recess being U-shaped to clear the cartridge in loading and ejection. Two lugs extending from the bottom of the breech ring were bored transversely to provide bearing for the breech operating crank in the general terminal crank. The top of the vertical sliding breechblock was U-shaped to guide the cartridge into the chamber and beveled on the front edge to secure final seating of the shell. An axial bore through the center of the breechblock housed the percussion mechanism. The percussion type firing mechanism was automatically cocked and manually released. A hand cocking lever was provided to recock the percussion mechanism when the breech was closed.

Hydropneumatic Recoil Mechanism T25, a modified Puteaux recoil type, had conventional action in recoil and counterrecoil. Final buffer action was regulated by setting the four-position orifice on the respirator head to allow the air which was drawn in on recoil to escape at the required rate.

Like the standard screw type elevating mechanism for field pieces, that of the 90-mm antitank carriage was equipped with handwheels on both right and left sides - that on the left for direct fire, that on the right for indirect firing. Maximum elevation was 375 mils, and maximum depression 181 mils. The traversing mechanism was a rack and pinion system, in which the traversing rack also served as a retaining ring for the outer race of the traversing bearing. A worm and worm wheel turned the vertical shaft and pinion. Stops limited total traverse to 1,047 mils.

The split-trail carriage (T5E2) was equipped with combat tires and segments for firing. Oblique armor plate shields were mounted on the top carriage and traversed with the gun. The axle support carried a horizontal pin on which the carriage was free to move approximately 5° from the main horizontal axis when the trails were spread, thus adapting to uneven terrain. Electric brakes controlled from the prime mover were ordinarily used in travel. An emergency system, depending on a 6-volt dry cell battery mounted on the right trail, provided electric power to apply brakes to carr. if became separated from the towing vehicle. For parking or firing hand brakes were provided.

Committee action on 13 January 1944 extended the project to include a new 90m/m antitank weapon to fullfil ASF requirements. Two additional pilots were to be manufactured according to the military characteristics outlined inthe letter of 2 November 1943, and were to incorporate specified changes which could not be made in the T8 gun and T5 carriage because the pilot models were in to advanced a stage. The new pilots were to carry the following designations: 90m/m Gun T13, Recoil Mechanism T39 and Gun Carriage T9. The recoilmechanism was of new design and similar to that for the 75m/m Pack Howitzer. Sighting equipment had not been determined at that time.

The 90m/m Gun Carriage T9 mounted the 90m/m Gun T13 on Recoil Mechanism T39. The gun was equipped with a double baffle muzzle brake, had a spring cushinoned semi-automatic breech operating mechanism with a "rollover" trigger sear for light pressure operation, and was attached to the recoil mechanism through a fastening ring on the breech. The carriage used the shield as a main structural member, had the trails mounted high on the shield, had the wheels mounted on the shield, fired from a retractable firing pedestal, and traveled with the trails folded underneath the muzzle and the tube locked to the trails. It was so balanced that its weight was transferred from wheels to firing pedestal by the swinging of the trails into firing position. The complete weapon weighed 6850 lbs.

At a conference of Army Ground Forces, Army Service Forces, Industrial Service and Research and Development Service representatives on 28 July 1944 it was decided to initiate two new 90m/m projects under supervision of the Artillery Division, Industrial Service to obtain a weapon which would better meet the requirements set by the Army Ground Forces. The first project called for the redesign of the parts of the T5E2 carriage which would be necessary to mount the T8 Gun equipped with a muzzle brake and this carriage ~~this e~~ designated T14 and the Gun T20. The second project was a complete new design of carriage with recoil mechanism to weigh approxcately 70001bs and to mount a gun equipped with a muzzle brake. The Carriage was designated T15 and the Gun T20E1.

f the Research and Development Service, development of gun carriage T9 for the T13 gun with muzzle brake and horizontal sliding breech block continued and when completed would be tested with the T14 and T15 to determine which if any would be selected for production for the remaining 400 carriages which were retained in the limited procurement program.

Along with 90-mm gun and carriage development ran a project to increase the muzzle velocity of the 90-mm projectile. The 2650 feet per second of the M82 projectile was to be raised to 2850 feet per second and placed under limited procurement in the Army Supply program with other materiel of this caliber to meet commitments to the Army Ground Forces.

It was evident that the weight of the T8 gun and the T5 carriage series would be excessive no matter how the combination was modified. Therefore development of the T13 gun and T9 carriage (similar to the 76-mm Gun T3 and Carriage T5) was expedited. The Carriage Branch requirements included a light trigger pull which meant the design of a new trigger mechanism. By December 1944 the mechanism was under manufacture at Watervliet Arsenal where it was assembled to the breech mechanism and shipped with the first pilot gun to the carriage manufacturer. To assist in balancing the carriage a modified (M3E1) muzzle brake was devised. This brake was reduced in weight and had a short front deflector.

Design studies for the T13 gun, T9 carriage, and recoil mechanism were under way by February 1944 and completed in April. Termination of the project was considered in May and June because the 90-mm T5E1 carriage was progressing more satisfactorily than anticipated, and the need for a high velocity 3-inch gun was thought to be more urgent. Thus the decision was made to convert the T9 to mount the high velocity 3-inch T16 gun. It was not until the end of the year that the T9 type carriage was considered again

. The project was picked up again in 1945 and a modified [illegible] was combined with a 90m/m Gun T13 as originally intended.

The T9E1 Carriage obtained very favorable comment on many of its features. It was, however, very difficult to emplace in positions where there was insufficient space to swing the trails. The T5E2 handwheel arrangement was superior to that used on the T9, but was unfortunately not adaptable to the T9 carriage.

At this stage it became evident that these weapons would not be required to complete the European campaign, and would not be needed in the Pacific Theater. Further, it was the opinion of the Tank Destroyer Board that towed artillery had very little application in antitank warfare unless it could be made extremely light without sacrificing any of the advantages of the current carriage types. Also, it should be of "super" velocity to give it an advantage of range and accuracy of tracking over the selfpropelled and armoured equipment. Consequently, it was recommended that no further production be made of any 90m/m towed gun carriages, and that development of the 90m/m Gun T8, Carriage T5E2, Gun T20 Carriage T15 and Gun T20E1 and Carriage T14 be terminated. It was however, recommended that the T9E1 Carriage and Gun T13 be further modified and resubmitted for test to determine the feasibility of the ~~type~~ this type design.

Both T9E1 pilots were modified to T9E2 by changing the trail hinge connection and providing and additional trail towing lock so that the weapon could be towed for short distances in the conventional manner, making it easier to emplace in restricted areas. Provision was also made for carrying the sight chest on a trail and for mounting Panoramic Telescope M12 with a new Telescope Mount M147, and a new Elevation Quadrant T20E1. The weapon weighed 6850 lbs. A pilot was sent to the Tank Destroyer Board, but this organization was disbanded before conclusive tests were made and the weapon was shipped to the Army Ground Forces Board No. 2 Fort Knox Ky.

During the above development period, several attempts were made to provide a super velocity 90m/m antitank carriage. A tank cannon, 90m/m Gun T15 (3200 Ft/sec.) was mounted as a mockup on the 90m/m Carriage T14 to test the road travel character-

eristics of such a combination. A 90m/m Gun T18 (3500 ft/sec.) was designed and built to develop ballistics. Layouts were made for a carriage (T19) to mount this weapon. A second cannon, 90m/m Gun T21, with ballistics identical with the T18, was laid out together with a carriage (T13) and recoil mechanism as a strictly antitank combination. All of these projects were cancelled in favor of the 105m/m Gun Carriage T19.

for mounting a 90-mm gun. The project was picked up again in 1945 and a modified (T9E1) carriage was combined with a 90-mm Gun T13 as originally intended.

Meanwhile the development of the T15 and T14 Carriages with the T20 and T20E1 guns progressed: The T20 and T20E1 guns which incorporate a horizontal sliding breech block and a Muzzle brake M3, differed only in the lug on the breech ring to which the recoil piston rod a is attached.

The 90-mm T14 carriage ~~is~~ the T5E2 type modified for the installation of the new cradle needed to mount the T20 gun. A new recoil mechanism (T52) of the Puteux type was designed. By October 1944 detail drawings of the recoil mechanism, sleigh, and cradle were released to the shop at Rock Island Arsenal for manufacture. Two carriages were scheduled to be finished in November. They were shop tested and shipped to Aberdeen Proving Ground in December. Firing and road tests were expected to be completed before the end of January 1945.

Here are the answers to some of the questions asked yesterday Wood

Parallel progress was made with the T15 carriage also intended for the T20 gun, which carried the T20E1 designation to distinguish it from those mounted on T14 carriages. Work on this carriage (T15), which resembled the 3-inch Gun Carriage M6 was also begun in July 1944. By October detail drawings were 75% complete and delivery of two pilot carriages and recoil mechanisms (T53) due on December first. Rock Island shipped both pilots to Aberdeen during December and preliminary firings were conducted immediately. The test program was expected to be finished by the middle of January 1945 after which one of the units was to go to

Camp Hood for service tests.

INCOMPLETE (Development continued after January 1945)

HIGH VELOCITY ANTITANK GUNS

A 90-mm gun was included in the general program initiated in 1944 for developing ~~high~~ Super velocity artillery weapons of several calibers. By increasing the chamber capacity and reducing the weight of the projectile a muzzle velocity of 3500 feet per second was expected.

The first of these experimental 90-mm high velocity antitank guns was designated T18 and was to be mounted on a carriage of new design (T19). Another super velocity gun (T21) was to use a muzzle brake and be mounted on the T13 carriage. Engineering and preliminary design studies for the carriages were executed in the fall of 1944, and a tentative design of the breech mechanism completed. But the carriage project was canceled in November, and work on the guns suspended. The reason for this was that the 105-mm gun, largest of the experimental high velocity series, appeared most promising -- all factors considered -- and further effort was to be centered upon its development. Obviously increasing the firepower of either the 3-inch or the 90-mm antitank gun, both of which were already in service and functioning satisfactorily, would not be as advantageous as developing a high velocity 105-mm antitank gun - increased in firepower first because of a higher muzzle velocity, and again because of its greater size.

An effort had been made in the summer of 1943 to adapt

the 105-mm antiaircraft gun to tank destroyer use. A gun was experimentally modified and designated T4 for mounting on a self-propelled carriage. This plan followed the same general pattern of the 3-inch gun which was experimentally mounted on the Cletrac. By the end of the summer the Tank Automotive Center was considering a new recoil system rather than the antiaircraft system which, if adopted, would completely change the design of the gun.

Consistent with normal practice for tank mounting, modifications were made to the T4 which provided a new breech ring and shortened the length of the tube. The modified pilot was designated T4E1. Requirements for mounting changed in the fall of 1943 and the T4E1 type gun was no longer desired. The project was canceled in December 1943. In line with new mounting requirements, however, a further modification to the pilot was made and the T4E2 was completed and assigned to Aberdeen Proving Ground as a proof facility.

Watervliet Arsenal completed the design of the next tank gun model, and submitted drawings for the T5 in January 1944. Manufacture of a pilot began, the breech ring castings were machined in February and tube forgings were due in March. By May the manufacture of the pilot was nearly complete but an improved T5E1 type was already desired. Two T5 tubes were delivered to Detroit and two to Aberdeen in June. The T5E1, which was 68 inches longer than the T5 so it might have the same interior ballistics as the T4, was expected to have a muzzle velocity of 3,000 feet per second.

In November 1944 work on the high velocity guns was suspended because of the decision to change ammunition from fixed rounds to separate, in order to reduce loading space required in tank turrets.

This did not affect the development of a similar antitank gun which was intended for a conventional split trail, towed carriage and which had been developed along with the tank gun since July 1943. The T8 gun (similar in design to the T5E1), Gun Carriage T19, and Recoil Mechanism T49 or T60 were to make up the towed 105-mm antitank weapon. The T49 and T60 recoil mechanisms differed in recoil and counterrecoil valve assembly. Both were modernized St. Chamond types.

A tube design for the T8 gun was completed by November 1944 and the muzzle velocity was calculated to be about 2,950 feet per second. This increase over the muzzle velocity of the T4E1 and T5 guns was attained by increasing the chamber capacity and reducing the weight of the projectile.

The towed 105-mm antitank carriage, ~~like the 90-mm T9~~, was to have 180° rotation of the top carriage so it might be drawn muzzle forward. Calculations set the total weight of the weapon at 16,000 pounds and the firepower was expected to exceed that of the 90-mm series appreciably.

Characteristics had not been more than tentatively determined at the end of December 1944. Development of artillery wheels composed of synthetic solid rubber tires on magnesium wheels was anticipated. A parallelogram rubber torque bushing assembly to provide spring suspension was considered, with torsion bar suspension an alternative type, and possible development. Work on this materiel is still highly experimental and has progressed slowly on low priority, as the final phases of the war do not appear to require weapons of this type.

(INCOMPLETE, THERE HAS BEEN DEVELOPMENT SINCE JANUARY 1945)

TYPICAL CHARACTERISTICS

90m/m Gun T8 and Gun Carriage T5E2

Gun Tube

Caliber	90m/m
Length, bore	50 Calibers
Gun tube (Overall)	186.15 in.
Weight	2280 Lb.
Rifling, number of grooves	32
Twist	1 turn in 32 calibers; Uniform, right hand
Pressure, maximum	38,000 lbs/sq. in.
Range	10,000 yds.

Recoil Mechanism

Model	T25
Type	Hydropneumatic
Recoil at 0 degree elevation	38 in.
At Maximum elevation	42 in.

Gun Carriage

Model	T5E2
Elevation, maximum	20 degree
Elevation, minimum	-10 degree
Handwheel effort to depress or elevate	8 lb.
Traverse	30 degree right 30 degree left
Handwheel effort to traverse	5 lb.
Length in traveling position	318 in.
Width in traveling position	96 in.
Road clearance	12 in.
Weight	7800 lbs.
Tires	11.00 X 20
Equilibrator, type	******

TYPICAL CHARACTERISTICS

90m/m Gun T20 and Gun Carriage T14

Gune Tube

Caliber	90m/m
Length, bore	50 calibers
Gun tube (Overall)	186.15 in.
Weight	1930 lb.
Rifling number of grooves	32
Twist	1 turn in 32 calibers; Uniform, right hand.
Pressure, Maximum	41,500 lbs/sq. in.
Range	10,000 yds.

Recoil Mechanism

Model	T52
Type	Hydropneumatic
Recoil at 0 degree elevation	20 in.
At maximum elevation	28 in.

Gun Carriage

Model	T14
Elevation, maximum	19degree 30 min.
Elevation minimum	-11 degree 11 min.
Handwheel effort to depress or elevate	40 lb.
Traverse	29 degree right 29 degree left
Handwheel effort to traverse	29 lb.
Length in traveling position	335 in.
Width in traveling position	99 in.
Road clearance	12 in.
Weight	7790 lb.
Tires	11.00 X 20
Equilibrator, type	*****

TYPICAL CHARACTERISTICS

90m/m Gun T20E1 Gun Carriage T15

Gun Tube

Caliber	90m/m
Length, bore	50 calibers
Gun tube (Overall)	186.15 in.
Weight	1940 lb.
Rifling number of grooves	32
Twist	1 turn in 32 calibers; Uniform, right hand
Pressure, maximum	38,000 lbs/sq. in.
Range	10,000 yds.

Recoil Mechanism

Model	T53
Type	Hydropneumatic
Recoil at 0 degree elevation	20 in.
At Maximum elevation	29.75 in.

Gun Carriage

Model	T15
Elevation, Maximum	22 degree 27 min.
Elevation, Minimum	-8 degree 32 min.
Handwheel effort to depress or elevate	66 lb.
Traverse	29 degree 40 min. right 29 degree 40 min. left
Handwheel effort to traverse	62 lb.
Length in traveling position	244 in.
Width in traveling position	99¼ in.
Road clearance	10¼ in.
Weight	7130 lb.
Tires	11.00 X 20
Equilibrator, type	*****

90m/m Gun T13 and Gun Carriage T9E2

Gun Tube

Caliber	90m/m
Length, bore	50 calibers
Gun tube (Overall)	177.15 in.
Weight	1532 lb.
Rifling, number of grooves	32
Twist	1 turn in 32 calibers; Uniform, right hand.
Pressure, maximum	38,000 lbs/sq. in.
Range	10,000 yds.

Recoil Mechanism

Model	T39
Type	Hydropneumatic
Recoil at 0 degree elevation	28 in.
At Maximum elevation	30 in.

Gun Carriage

Model	T9E2
Elevation, maximum	20 degree
Elevation minimum	-8 degree
Handwheel effort to depress or elevate	10 lb.
Traverse	30 degree right 30 degree left
Handwheel effort to traverse	8 lb
Length in traveling position	225 in.
Width in traveling position	85.5 in.
Road clearance	12 in.
Weight	6850 lb.
Tires	9.00 X 20 combat
Equilibrator, type	*******

TYPICAL CHARACTERISTICS

90m/m Gun T15

Gun Tube

Caliber	90m/m
Length, bore	70 calibers
Gun tube (Overall)	257¼ in.
Weight	3424 lb.
Rifling, number of grooves	32
Twist	1 turn in 32 calibers; Uniform, right hand
Pressure Maximum	41,500 lbs/sq. in.
Range	

TM 9-375 90m/m Gun T8 and 90m/m Gun Carriage T5E2

OCM 20126 Antitank Materiel 90m/m, 90m/m Gun T8, Recoil Mechanism T25, and 90m/m Gun Carriage, T5 Development Recommended.

OCM 20293 Antitank Materiel 90m/m, 90m/m Gun T8, Recoil Mechanism T25, and 90m/m Gun Carriage, T5 Approval of Development.

OCM 22640 Extension of Development Project Approval by Item 20293 to include Gun 90m/m T13 Mechanism Recoil, T39 and Carriage, Gun 90m/m, T9.

OCM 26440 Carriage Gun 90m/m, T9E1 for Gun, 90m/m, T13 Using Mechanism, Recoil, T39 Assignment of Model Disignation and Status of Development Project.

OCM 26647 Carriage Gun 90m/m, T9E1 for Gun, 90m/m, T13 and Using Mechanism, Recoil, T39 Changes in Item 26440.

OCM 26936 Carriage, Gun 90m/m, T9E2 for Gun, 90m/m, T13 Using Mechanism Recoil, T39 Assignment of Model Disignation and Status of Development Project.

OCM27840 Carriage, Gun, 90m/m, T5E2, Mechanism, Recoil, T25; and Gun, 90m/m T8- Action Relative to Quantities to be procured on the Basis of Status of 90m/m, Antitank Gun Development Program: Approved.

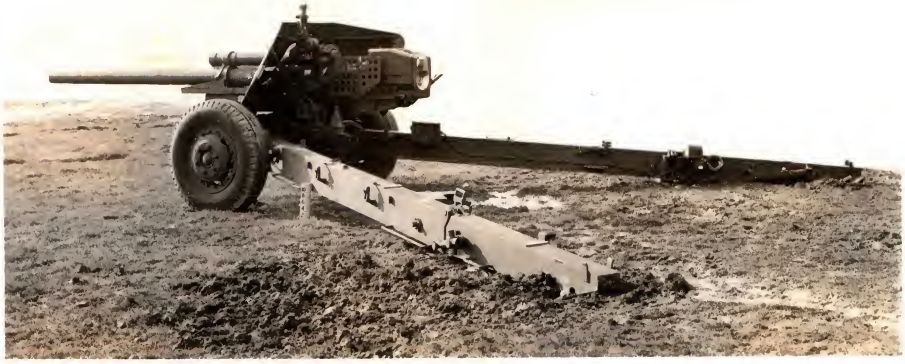
OCM 27435 Gun, 90m/m, T5E2, Mechanism, Recoil, T25, and Guns 90m/m, T8 Action Relative to Quantities to be Procured Recommended on the Basis of Status of 90m/m, Antitank Gun Development Program.

OCM 25018 Gun 90m/m, T8, Carriage, Gun, 90m/m, T5E2, Materiel Classification as Limited Procurement type and Procurement of 200 Recommended; Day of Supply of ammunition also Recommended. Gun 90m/m, T20, Carriages, Gun, 90m/m, T14 and T15 Development Recommended.

OCM 25407 Gun 90m/m, T8, Carriage, Gun, 90m/m, T5E2, Materiel Classification as Limited Procurement type and Procurement of 200 Approved; Day of Supply of ammunition also Approved, Gun 90m/m, T20, Carriages, Gun, 90m/m, T14 and T15 Development Approved.

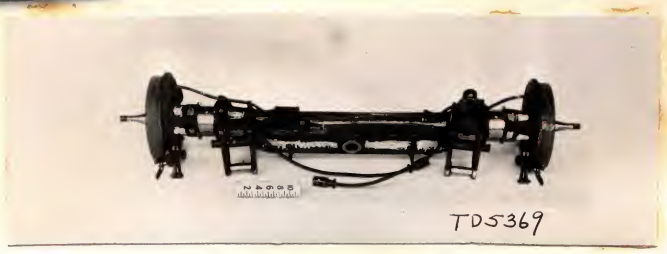
90 MM GUN CARRIAGES T9E1,
T15, T5E2 AND T14
FRONT REAR

90 MM GUN CARRIAGES T9E1,
T15, T5E2 AND T14



90 MM GUN CARRIAGE T5

90 MM GUN CARRIAGE T5



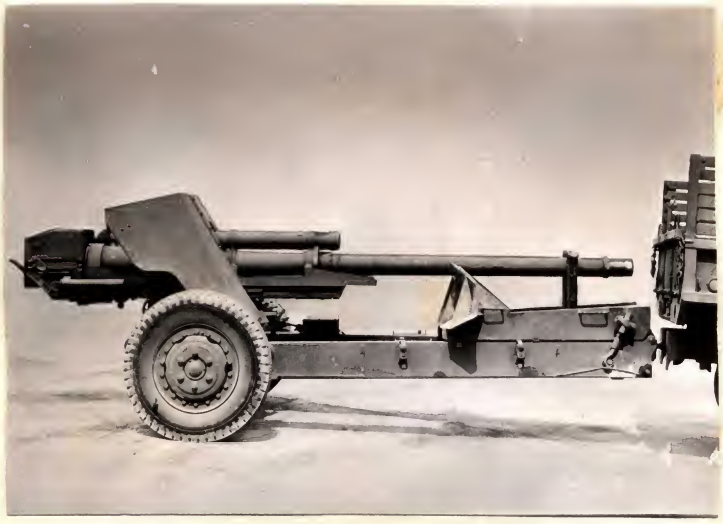
TD 5369

Exhibit 9

90-mm Antitank Gun Carriage T5

TD 5405

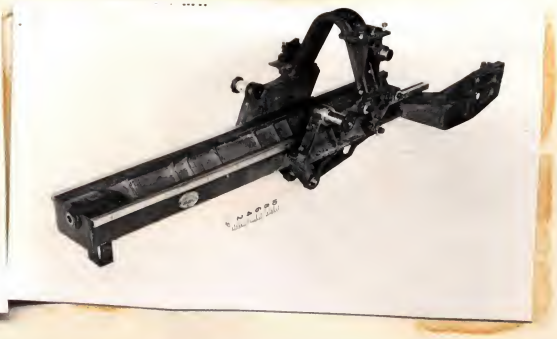
90-mm Antitank Gun T8, with 90-mm Gun Tube T8



TD 5378

90-mm Antitank Gun Carriage T5 in traveling position

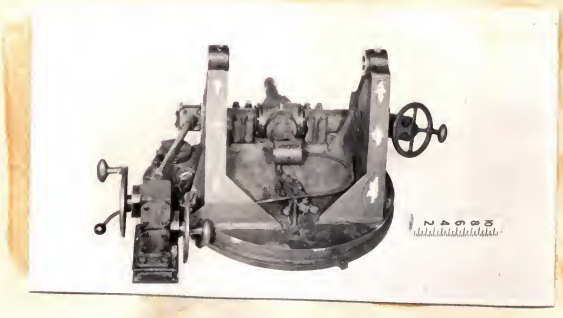
TD 5406



TD 5380

90-mm Antitank Gun Carriage T5, Cradle assembly

(D7105639)



TD 5381

TD 5407

Top Carriage, with elevation mechanism and traversing mechanism assembled. 90-mm Gun Carriage T5

90-mm Gun Carriage T5, trail assembly

(D7105731)

90 MM GUN CARRIAGE T5E1

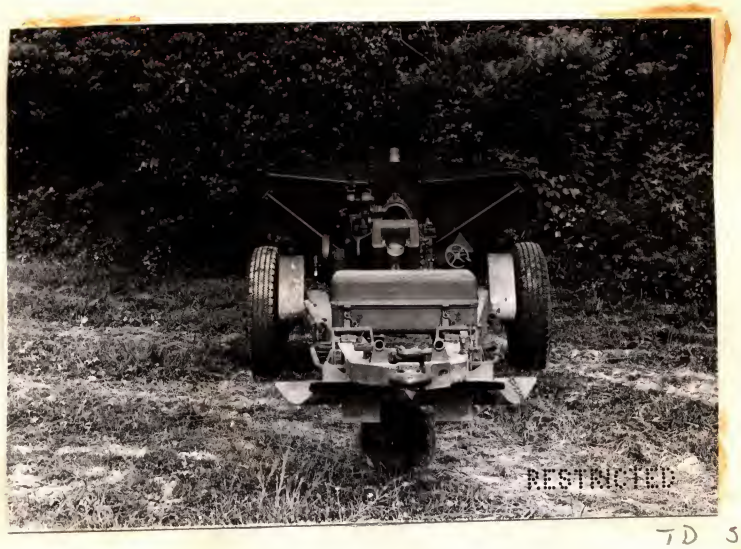
90 MM GUN CARRIAGE T5E1

90 MM GUN CARRIAGE T5E2

90 MM GUN CARRIAGE T5E2

TD 5376

90-mm Gun Carriage T5E1, front, in traveling position



TD 5377

90-mm Gun Carriage T5E1, rear, in traveling position

90-mm Antitank
Gun Carriage ~~T3A1~~ T5E1

TD 2084

90-mm Antitank
Gun CARRIAGE T5

TD 2272

90-mm Antitank Gun T8
on 90-mm Gun Carriage
T5E2

TD 2464

TD 5393

90-mm Gun Carriage T14, front, traveling position

TD 5396

90-mm Gun Carriage T14, firing position at 0° elevation, right side view.

TD 5394

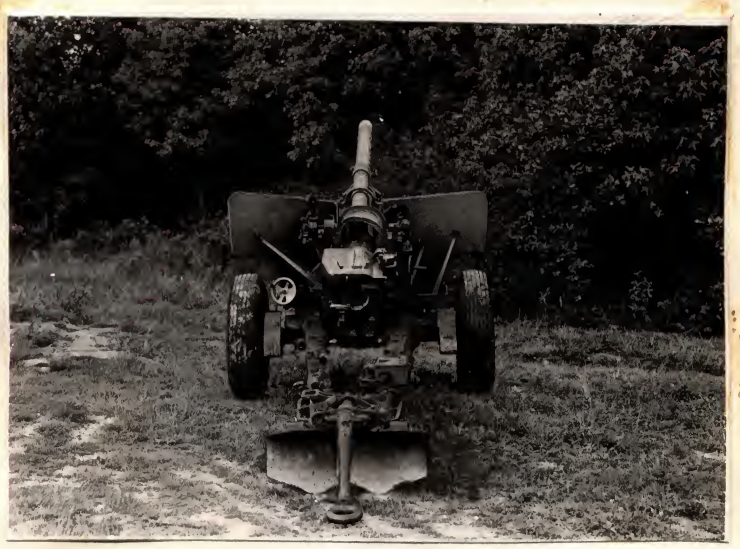
90-mm Gun Carriage T15, firing position at maximum depression, 3/4 left front view.

TD 5395

90-mm Gun Carriage T15, traveling position front view

TD 5367

90-mm Gun T8 on 3-Inch Gun Carriage M6, right side



TD 5365

90-mm Gun T8 on 3-Inch Gun Carriage M6, rear

(both views show carriage in
traveling position)

TD 5366

90-mm Gun T8 on 3-Inch Gun Carriage M6
(traveling position, right front view)

CARRIAGE DEVELOPMENT

As has been mentioned previously, the 105m/m Howitzer M2A1 on carriage M2 was considered as a possible antitank weapon. Later, it was desired that this weapon be able to protect its position against tank attack, even though not used primarily as an antitank weapon. In September, 1942, a project was indertaken to develop a new 105m/m Howitzer Carriage T8 which would eliminate some of the deficiencies of the M2 Carriage and, by sacrificing extreme elevations, be more adaptable to antitank operations. Drawings were made, but the project was cancelled in April, 1943, due to more recent combat experience which indicated the need for maximum elevations of fire.

The 105m/m Gun T8 was an outgrowth of the T5E1 tank gun, having the same ballistics (2950 Ft/ sec.) and using the same ammunition but being designed primarily for a field carriage. This weapon was designed to provide greater fire power then the 90m/m Antitank Guns. Preliminary layouts for 105m/m Gun Carriage T19 and Recoil Mechanism T49 were begun in October, 1944. Design and construction of pilots was begun in January, 1945.

Owing to the extreme length of the weapon, (65 Calibers) it was necessary to provide some means of shortening the towed load. The carriage was too heavy to permit placing on a firing jack by swinging the trails forward as in the 90m/m Gun Carriage T9E2. It was, therefore, decided to rotate the gun through 180 degree and lock the tube to the trails for traveling. 90,000 p.s.i. yield point steel weldments were used to effect maximum weight saving. A torsion bar suspension system was combined with a system for equalizing wheel height in firing position. Solid rubber tires were supplied in addition to pneumatic tires to test the applicability of the former. Air brakes were furnished on the T19, and a second design., T19E1, provided electric brakes for comparison. A second type of recoil mechanism with a new method of valving was built and designated Recoil Mechanism T60. The complete weapon weighs 14,300 lbs.

(Artillery wheel T1, T1E1 T1E2, & T1E3)

The project originally provided four pilots, but two were cancelled at the end of the war in Europe. The project was initially conceived to provide the ultimate in powerful towed weapons for antitank use.

TYPICAL CHARACTERISTICS

105m/m Gun T8 Gun Carriage T19

Gun Tube

Caliber	105m/m
Length, Bore	67 calibers
Gun tube (Overall)	268.81 in.
Weight	5260 lb.
Rifling number of grooves	36
Twist	1 turn in 30 calibers Uniform right hand
Pressure maximum	42,000 lbs/sq, in.
Range	25,000 yds.

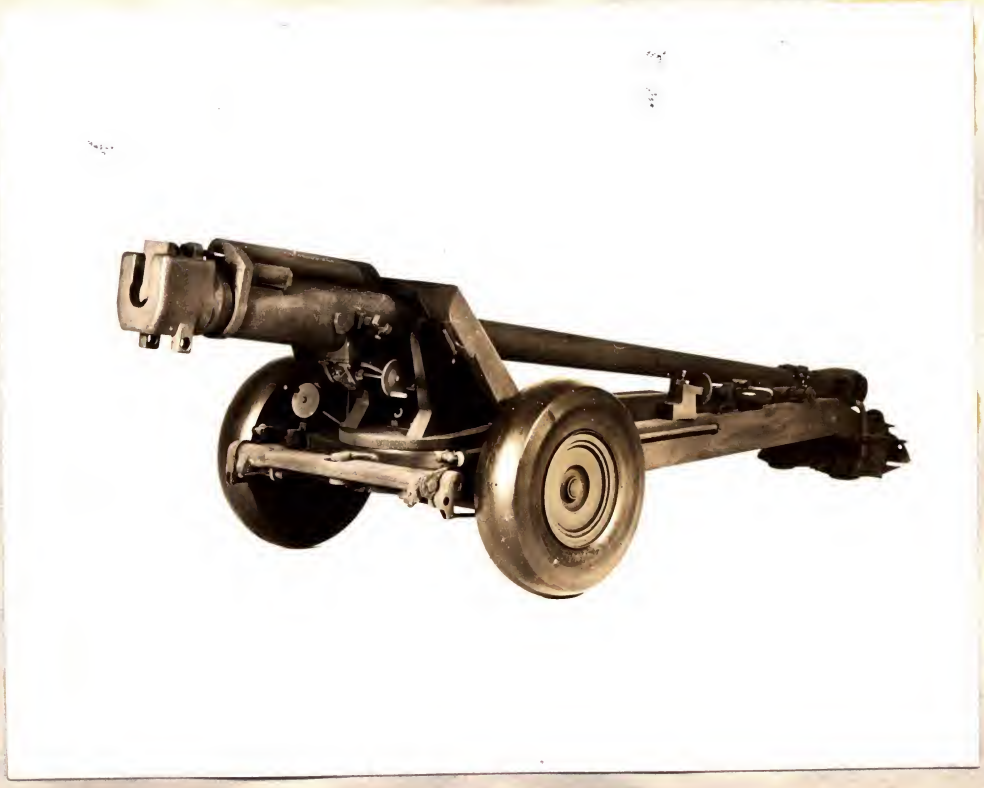
Recoil Mechanism

Model	T49 and T60
Type	Hydropneumatic
Recoil at 0 degree elevation	18 in.
At Maximum elevation	20 in.

Gun Carriage

Model	T19
Elevation maximum	46 degree
Elevation minimum	-7 degree
Handwheel effort to depress or elevate	50 lb.
Traverse	30 degree right 30 degree left
Handwheel effort to traverse	50 lb.
Length in traveling position	319 in.
Width in traveling position	108 in.
Road clearance	16.5 in.
Weight	14,430 lb.
Tires	14.00 X 24
Equilibrator	*******

105 MM GUN CARRIAGE T19



105 MM GUN CARRIAGE T19

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